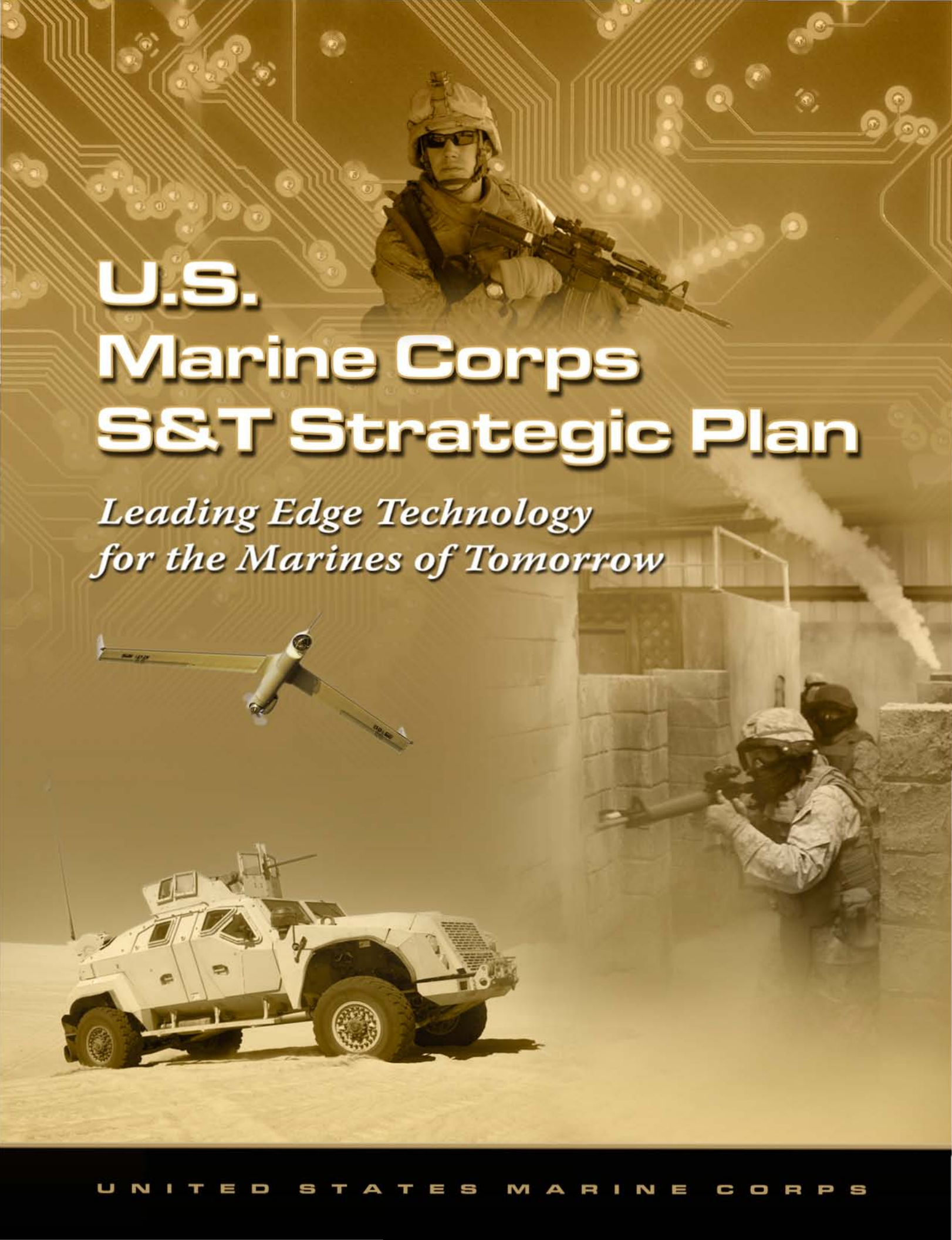

U.S. Marine Corps S&T Strategic Plan

Leading Edge Technology for the Marines of Tomorrow

UNITED STATES MARINE CORPS

Report Documentation Page

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MARINE CORPS SCIENCE AND TECHNOLOGY STRATEGIC PLAN

29 July 2009

The *Marine Corps Science and Technology Strategic Plan* establishes the priorities and provides direction for investment in science and technology needed to enable our future Marine Corps. As you read this Plan, you will find that it addresses capability needs for all the elements of our Marine Air-Ground Task Force as well as key enabling needs resourced by the Navy to support the Sea Base, Naval Aviation, and Naval Medicine and Human Performance.

The Plan is designed to complement the *Marine Corps Expeditionary Maneuver Warfare Capability List* by identifying as science and technology objectives – STOs – the technology enhancements most needed to enable the warfighting capabilities of our future operating forces. The STOs are not intended to be all-inclusive. Instead, they identify the priority S&T objectives needed to implement our vision for the 21st century Marine Corps as articulated in *Marine Corps Vision & Strategy 2025* and our capstone concepts for the future.

You will note that the Plan continues to focus on the needs of the individual Marine -- specifically that of the Marine at the tactical level -- operating in an irregular warfare environment. In keeping with this theme taken from *Marine Corps Vision & Strategy 2025*, we have added sections in this plan that focus specifically on Escalation of Force and Irregular Warfare. In addition, we have moved Training & Education from an Annex into the body of the Plan in recognition of its inherent contribution to enabling combat capability across all of the warfighting functions.

At the same time, we continue to identify capability gaps that call for S&T investment within all of the warfighting functions necessary if we are to operate effectively across the full spectrum of operations. This will require investment in the technologies that will provide improved individual communications, tactical mobility, and networked intelligence down to the squad level.

While we continue to focus on the individual Marine in the context of a Marine Air-Ground Task Force, this Plan recognizes our need for technologies that will make us more energy efficient, both in the operating forces and in our facilities. Not only are energy technologies a key component in *lightening the load* of our dismounted forces but they also are key to reducing the sustainment footprint in the expeditionary environment, improving the efficiency of our facilities across our Corps, and in reducing the energy vulnerabilities of our nation.

GEORGE J. FLYNN
Lieutenant General, U.S. Marine Corps
Deputy Commandant for Combat Development and Integration

Marine Corps Science and Technology Strategic Plan

Ref: (a) Marine Corps Vision & Strategy 2025
(b) MCO 3900.15B; Marine Corps Expeditionary Force Development System (EFDS)
(c) Naval S&T Strategic Plan: Defining the Strategic Direction for Tomorrow, 2009
(d) POM-12 MAGTF Capabilities List (MCL)
(e) POM-12 MAGTF Gap List (MGL)
(f) POM-12 Solutions Planning Directive (SPD)
(g) U.S. Marine Corps Science & Technology Campaign Plan FY 2009

Annexes: (A) Seabasing
(B) Aviation
(C) Naval Medicine and Human Performance

1. **Purpose**. To provide the combat developer's strategic guidance for the Marine Corps Science & Technology (S&T) enterprise. This plan focuses Marine Corps S&T efforts to pursue S&T initiatives and support experimentation of concept-based capabilities in accordance with the vision set forth in reference (a) and through the Expeditionary Force Development System described in reference (b).

2. **Background**

a. The Marine Corps S&T enterprise is an integral part of the larger Naval Research Enterprise (NRE). It is a collaborative effort led by the Deputy Commandant, Combat Development & Integration (DC, CD&I), but inherently involves the Marine Corps Systems Command (MCSC), the Program Executive Office, Land Systems (PEO, LS), and the Office of Naval Research (ONR). This relationship is depicted in Figure 1.

b. The Commandant of the Marine Corps provides the future vision for the Marine Corps based on strategic guidance as currently defined in reference (a). The DC, CD&I expands on the CMC's vision by developing Marine Corps warfighting concepts and determines required capabilities through Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities (DOTMLPF) analysis to enable the Marine Corps to field combat-ready and relevant forces. Marine Corps S&T is an integral part of the EFDS process and the Science & Technology Objectives (STO) articulated in this strategic plan are products of that process and are developed in coordination within the Marine Corps S&T enterprise.

c. DC, CD&I is the combat developer and integrator for the Marine Corps, the MCSC and PEO, LS serve as the materiel developer, and the ONR serves as the technology developer for the Department of the Navy (Navy and Marine Corps). Coalescing these responsibilities requires a synergistic partnership with a common vision, strategy, and an implementing plan. Staff responsibility for coordinating Marine Corps S&T combat development efforts is assigned by DC, CD&I to the Commanding General, Marine Corps Warfighting Laboratory under the title of Executive Agent for Marine Corps S&T (EA, S&T). Within MCWL, the Office of S&T Integration is tasked with executing that responsibility. An S&T Integrated Product Team with broad membership across the community of interest as reflected in Figure 1 supports the EA for S&T in this coordination role.

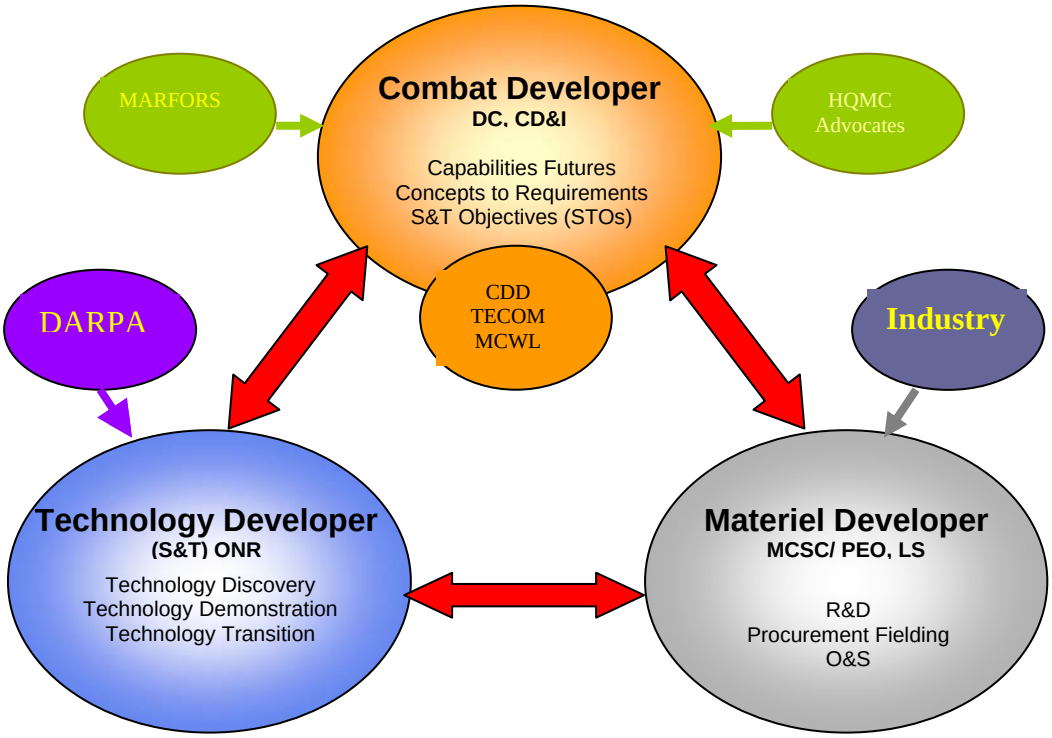


Figure 1

d. The *Marine Corps S&T Strategic Plan* is based on the S&T guidance of the Office of the Secretary of Defense and that of the Department of the Navy in reference (c) as approved by the Naval S&T Corporate Board. The Naval S&T Corporate Board consists of the Assistant Secretary of the Navy for Research, Development, and Acquisition (ASN, RDA), the Vice Chief of Naval Operations (VCNO), and the Assistant Commandant of the Marine Corps (ACMC). In addition, the Marine Corps S&T Strategic Plan is derived as an inherent function of the EFDS.

e. The EFDS is used to develop future warfighting capabilities to meet national security objectives. This system guides the identification, development, and integration of Warfighting and associated support and infrastructure capabilities for the MAGTF. EFDS is a deliberate, four-phased process that is executed cyclically and is synchronized with the Planning, Programming, Budgeting, and Execution System (PPBES) and the Defense Acquisition System.

f. EFDS is a coordinated effort, led by the combat developer (DC, CD&I) and involving participation in all phases by the Deputy Commandants (DC) / MAGTF advocates; COMMARFORS; DoN Deputy CIO (MC), the functional advocates (Director, Intelligence and Director, C4); Commander, MCSC, and PEO, LS. The major products of interest for S&T are the MCL, MGL, and the SPD as depicted below in Figure 2. It is chiefly through participation in EFDS and developing these products that Marine Corps S&T integrates with the combat development process. The STOs contained in this plan are the result of continuous engagement and participation by the Marine Corps S&T community in the combat development process and reflect those areas where Marine S&T can contribute to the development of future Marine Corps warfighting capabilities.

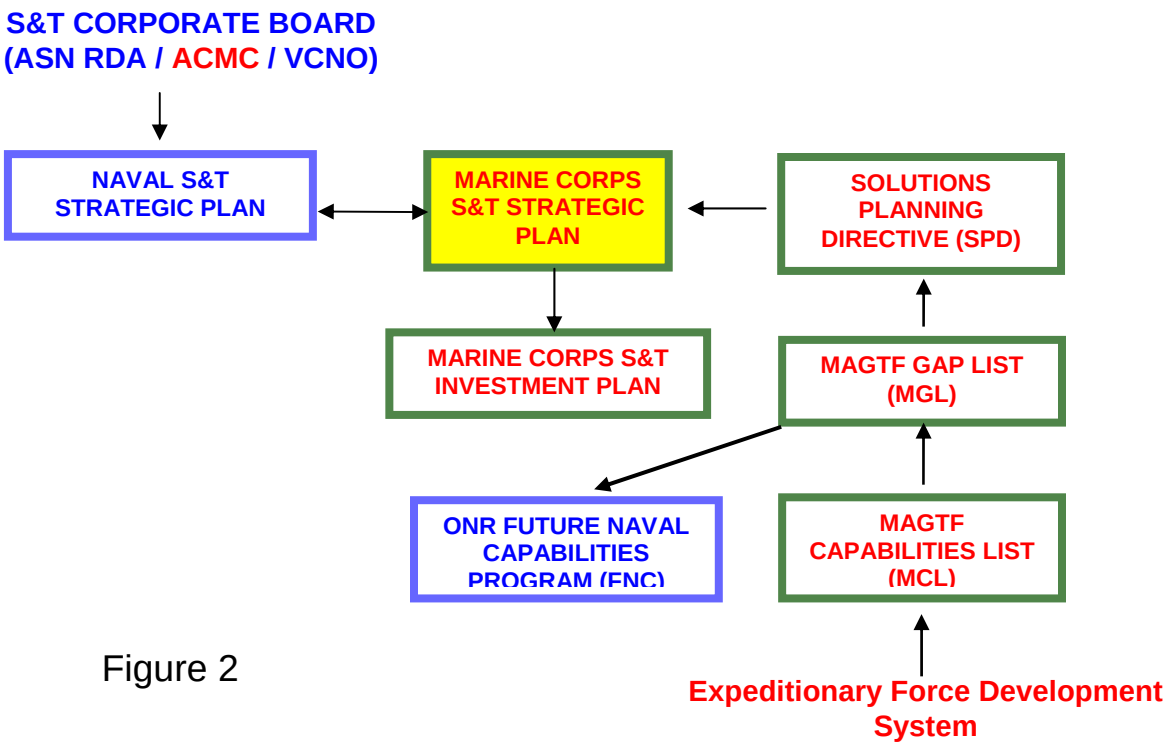


Figure 2

g. The Marine Corps leverages the investments of ONR, the Defense Advanced Research Projects Agency (DARPA), other Services-- specifically that of the Army[1] -- and industry while focusing our Marine Corps unique investment to support Marine Corps combat development and future materiel needs. This approach ensures that we are meeting our near-term needs focused primarily on those of the current operating forces; our mid-range needs – primarily those of the materiel developer in technology enhancements to acquisition programs for the next Marine Corps; and the far-term needs of the "Marine Corps After Next" as articulated in our future concepts.

3. **Capability Needs**

a. Marine Corps capability needs are determined as a result of the EFDS and articulated principally through reference (d) and as identified in Universal Needs Statements (UNS), Statement of Needs (SON) Documents, Initial Capability Documents, Capability Development Documents, and Capability Production Documents.

b. Marine Corps S&T capability gaps, developed during the EFDS process and articulated through reference (e) represent shortfalls in our ability to meet capability needs. In addition to providing the baseline for developing the Solution Planning Directive, the capability gaps are also integrated into the Navy's S&T gap analysis process that supports the Future Naval Capabilities (FNC) program. The goal of the FNC is to ensure that a defined portion of the ONR S&T investment focuses specifically on transitioning technologies into naval acquisition programs targeted at priority warfighting capability gaps. Engagement by the Marine Corps in this

inherently naval process ensures that we compete for funding and programs in the larger naval S&T arena.

c. During the development of the SPD, Marine Corps S&T participation peaks in influencing specific technical solutions ("art of the possible") in the combat development continuum. During SPD development, solutions are explored and identified as desirable solutions to close the gaps articulated in reference (e). This is where S&T inputs to the proposed solutions are developed and documented.

4. **Assumptions**

a. Marine Corps-unique expeditionary maneuver warfare capabilities and naval character remain relevant and essential.

b. Marine Corps core competencies as contained in reference (b) and principal warfighting concepts remain unchanged.

c. S&T resources available to the Marine Corps remain relatively stable based on the PR09 profile. Department of the Navy S&T resources remain at approximately 0% - 3% real growth across the FYDP.

d. Marine Corps warfighting functions remain unchanged.

e. Capabilities identified in emerging concepts in support of distributed operations, enhanced company operations, enhanced MAGTF operations, urban operations, irregular warfare, and / or hybrid warfare will influence S&T investment as will lessons learned from combat operations.

5. **S&T Budget Categories**

a. The Department of Defense delineates budget activities with specific funding categories for science and technology known as: basic research, applied research, and advanced technology development.

(1) Basic Research (6.1) includes scientific study and research to increase knowledge and understanding in the physical, engineering, environmental, and life sciences related to long-term naval needs. Its focus is knowledge of scientific phenomena. Discovery and Invention (D&I) is the responsibility of ONR and current research areas of primary interest to the Marine Corps are:

- Robotics and Autonomous Systems
- Communications
- Lightweight Power Sources
- Information Efficiency and Networks
- Sensing
- Human Performance

- Landmine and Improvised Explosive Device (IED) countermeasures (to include both detection, induced pre-detonation, and survivability)
- Energetic Materials
- Irregular, Urban/Asymmetric Warfare
- Small Unit Excellence

(2) Applied Research (6.2) is the systematic study to understand the means to meet recognized and specific naval needs. Applied research translates promising basic research into solutions for broadly defined military needs, short of system development projects. Its focus is proving technology feasibility when applied to solving military problems. It includes D&I technology efforts.

(3) Advanced Technology Development (6.3) includes the development of subsystems and components and the efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment. The focus is on demonstrating the military utility of technologies and applying them to acquisition programs. It supports the FNC program, as well as the warfighting experimentation conducted by MCWL.

6. **Science & Technology Objectives (STO)**

a. STOs are developed as part of the EFDS process and in response to strategic guidance articulated in documents such as reference (a). The STOs provide combat development guidance to the S&T community, primarily within the NRE, but also to other Services, defense agencies, industry, and academia. A STO states a major technological advancement to be achieved and is in support of a capability need identified and prioritized during S&T gap analysis. STOs state the overall S&T "requirement."

b. The STOs are developed by the EFDS Functional Working Groups (FWG) under the guidance of the S&T IPT. Each FWG draws membership from the "three circles" (Figure 1) to ensure that the STOs are coordinated and S&T offers an appropriate solution opportunity.

c. In keeping with the Marine Corps participation in the NRE, the STOs are also the principal driver for Navy S&T investment in the land warfare component of naval expeditionary warfare as articulated in reference (c).

d. The organization of this Plan mirrors the six-warfighting functions inherent to the framework of the MCL, MGL, and the SPD (Command and Control, Intelligence, Maneuver, Fires, Force Protection, and Logistics) as contained in references (d) through (f). Warfighting functions assist commanders in achieving unity of effort to build and sustain combat power when

used in concert, and should not be viewed independently but rather as inseparable parts of a whole. Each warfighting function is designed to depict the linkage of the general statement, vision, and goal to the individual STOs. In recognition that not all areas of significant importance to the Marine Corps fit into the six warfighting functions, we have included three additional areas in the main body of this strategic plan. These areas of significant importance are Training and Education, Escalation of Force, and Irregular Warfare.

e. The *maneuver* functional area specifically addresses the area of *mine countermeasures* which includes technology responses to the threat of IEDs and unexploded ordnance in keeping with the emphasis currently placed on this warfighting gap through extensive investment outside of the DoN. Two interconnected combat development working groups (Mine Counter Measures under the lead of DC, PP&O and the IED Working Group under the lead of the CG, MCWL) are focused on closing this significant warfighting gap.

f. In recognition of the fact that various functions are not "warfighting" functions, and are primarily funded by "blue dollars," but are of significant importance to the Marine Corps, we have included three Annexes in this plan. These are Aviation, Seabasing, and Naval Medicine and Human Performance. Expenditures for seabasing, aviation, and medical science and human performance STOs are Navy *blue* dollars and capability gaps are developed via the Navy capability gap process as well as through the Marine Corps EFDS process.

7. **Marine Corps S&T in support of America, British, Canadian, Australian (ABCA), and New Zealand Coalition Interoperability Program**

a. One venue for Marine Corps participation in, and benefit from other nation's S&T efforts, is the ABCA program. While the program is not an alliance, these nations have served together in ad hoc coalitions on numerous occasions to pursue common objectives. The Technical Cooperation Program (TTCP) is the primary forum for S&T collaboration between the defense establishments of the ABCA nations.

b. The U.S. Marine Corps, is an "associate member" of the ABCA Armies Program, and as such engages with ABCA as a member of the US delegation, led by the US Army.

c. Assigned by the EA for S&T, the Marine Corps representative to the ABCA S&T effort will engage with members of the Marine Corps S&T enterprise to provide information and opportunities on the ABCA S&T program and priorities.[2]

8. **Marine Corps S&T Program Elements (PEs)**

a. The Marine Corps programs resources for S&T efforts through four Marine Corps PEs identified in the Defense budget. Two of these PEs support Joint Non-Lethal Weapons Directorate activities. The remaining two support applied research (6.2) activities and advanced technology development (6.3) efforts -- to include that of the MCWL concept-based experimentation efforts.

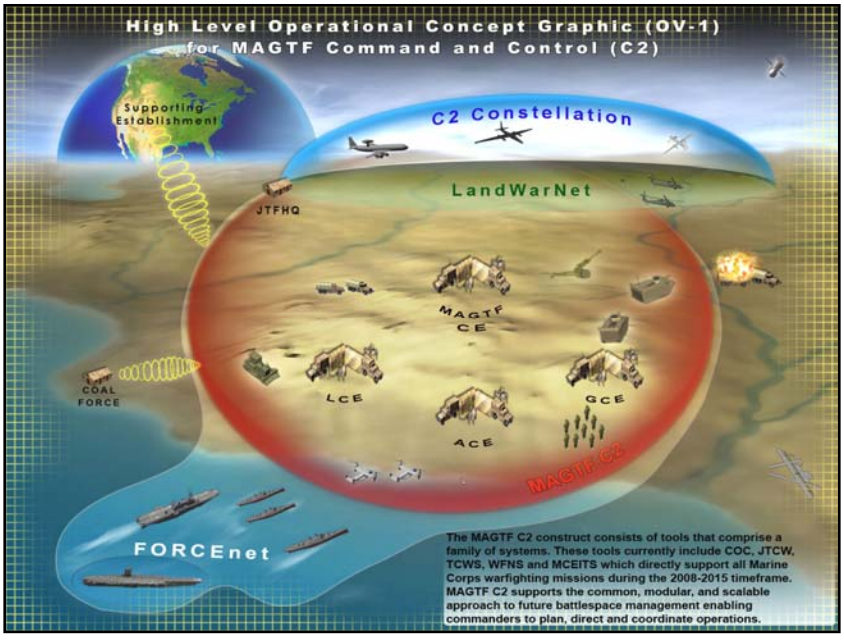
b. All four Marine Corps programmed PEs are administered by the Deputy Chief of Naval Research (Expeditionary Maneuver Warfare & Combating Terrorism) at ONR 30 in his CNR assigned role as Director, Marine Corps S&T[3]. Updated annually, reference (g) is published by the Director, Marine Corps S&T to present the portfolio of Marine Corps funded S&T programs and align those investments with the Marine Corps S&T needs and expectations as defined by the STOs within the current revision of the *Marine Corps S&T Strategic Plan*.

Command and Control

Marine Air-Ground Task Force Command and Control (MAGTF C2) is the strategy by which the Marine Corps will implement the Naval *FORCEnet Functional Concept* and is the functional and conceptual equivalent to the other Service's net-centric concepts of *LandWarNet* (Army) and *C2 Constellation* (Air Force). The S&T investment in Command and Control is focused on three areas required to implement MAGTF C2: (1) communications and networking systems to enable data exchange with and among distributed tactical forces; (2) decision support systems; and (3) effective combat identification of enemy combatants, friendly forces, and non-combatants.

<u>The Vision</u>: Our C2 systems must enhance mission command and control and give subordinates sufficient understanding of the situation and the commander's intent before the battle, while encouraging initiative and creativity once the fight is joined. The end state is a "born joint," common, scalable, modular MAGTF C2 capability, seamlessly employable on land and at sea, enhancing the lethality and effectiveness of the MAGTF across the range of military operations through better decision-making, collaboration, and shared understanding. The objective is to provide a holistic, end-to-end, turnkey C2 capability to execute commander's intent, facilitate implicit communications, visualize battlespace "reality," promote initiative, enable centralized command and decentralized control, and ultimately accomplish the mission.[4]

<u>Goal</u>: *Integration of all force elements throughout the battlespace and across the range of military operations (ROMO) including attended and unattended space, air, ground and sea sensors down to the individual warfighter. "Flagpole to fighting hole," forces, activities and platforms are interconnected in this networked, collaborative command and control environment, thereby benefiting from the advantages of decentralization (e.g. initiative, adaptability, and*



increased tempo) without sacrificing the coordination or unity of effort typically associated with centralization. These systems provide a shared understanding of position location information (PLI) on friendly forces, and incorporate combat identification technology to facilitate distinguishing combatant forces. Commanders at all levels are able to gain and maintain situational awareness, make better decisions, and exercise authority and direction over assigned forces via an adaptable, distributive, and seamless system.

-- C2 STO-1: Converged service networks with assured, robust communications linking all echelons of the MAGTF

Develop network centric warfare technologies that enable early entry forces to communicate over the horizon, beyond line of sight and on the move (OTH/BLOS/OTM)[5] with each other, and interoperate with other naval, joint, and coalition forces to enable distributed maneuver, and to leverage joint fires, intelligence and logistics on the future battlefield.

-- C2 STO-2: Multilevel information security and information assurance

Develop technologies that facilitate information sharing (down to the platform level) and enable the integration of unclassified and classified systems for joint and coalition operations. Provide intra-, cross-, and inter-domain authentication, encryption, and information assurance/integrity services in conditions typical to Marine Corps operations, such as intermittent connectivity and limited throughput in restricted and hostile environments.

-- C2 STO-3: Intelligent network planning, monitoring, maintenance, and mobility

Develop intelligent network management technologies to enable network planning, real time monitoring, maintenance, and distribution of the network status. Provide technologies that include the capability to employ modeling and simulation (M&S) techniques to evaluate network performance, enable automatic recovery, alerting, and net intrusion countermeasures; and graceful network reconfiguration and/or degradation as nodes are lost and recovered.

-- C2 STO-4: Improved situational awareness for warfighters at all echelons

Develop improved situational awareness capabilities that operate with high levels of automation to provide Marines (across all echelons and elements of the MAGTF) intelligent access to digital information. Enable near-real time distribution of tailored information using cognitive tools, intelligent agents, tailored services, and other relevant technologies. Develop interactive, non-intrusive situational awareness assessment metrics to enable improved mission planning and team training interventions.

-- C2 STO-5: Blue force tracking/PLI/combat ID

Develop passive and active methods for timely determination of location and identity of battlespace entities. Provide tools for training, discovery, retrieval and presentation of most relevant/highest quality location and identification data regardless of source.

-- C2 STO-6: Collaborative planning and synchronized execution

Develop intuitive non-user-intensive decision aids and collaborative planning tools tailored for mission, location and echelon appropriate for the distributed Battlespace. Facilitate dynamic and rapid mission adaptation through transparent user information pull and automated information push**.**

Intelligence

The S&T investment in intelligence is directed toward development of a comprehensive Intelligence, Surveillance, and Reconnaissance (ISR) capability set that supports all elements of the intelligence cycle: Planning and Direction, Collection, Processing and Exploitation, Production, Dissemination, and Utilization.

***The Vision:* Commanders at all levels have both the capability to leverage the Joint ISR architecture, and to conduct reconnaissance, surveillance, and target acquisition functions commensurate with their mission, with assets that they control[6], and with the ability to quickly and succinctly move data across the battlefield down to squad-level elements.**

Goal: To identify and develop a more responsive, comprehensive ability for commanders at all levels to collect and analyze data, develop useable intelligence products, and then quickly distribute relevant intelligence products to users across the battlefield. To achieve this goal, data and information must be capable of flowing seamlessly across the battlefield in formats and quantities that allow tactical units very specific access to integrated sensor data, communication across significant distance, and the ability to access joint intelligence and operational expertise. We are exponentially increasing our ability to gain access to significant, sometimes overwhelming, amounts of data. The ability to intelligently and precisely filter and automate processing of much of this data is critical to our capacity to ingest it into our decision-making cycle and to provide information which is urgently relevant to the current situation. Science and technology must help commanders and small unit leader's access and move data in a manner that accelerates our ability to selectively and intelligently integrate key intelligence into current operations in such a way that we positively influence the results of operations.

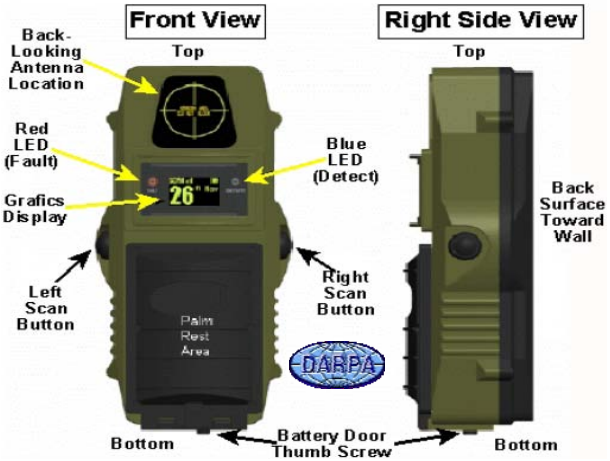
-- Intel STO-1: Enable smart sensor field planning and management

Develop automated planning tools that enable the design of multi-INT sensor collection plans that are optimized for specific information requirements at all command levels. Such tools specify the sensor types and densities needed to collect against specific information requirements. Develop tools that can autonomously manage and task large numbers of netted sensors.

-- Intel STO-2: Provide quality tactical sensing

Develop small, smart, lightweight, low-power, network enabled sensors that provide situational awareness and understanding and can be deployed at the battalion level and below. Sensors that can clandestinely collect relevant tactical information in denied areas are also needed. These sensors will be capable of sensing unique features or behaviors of entities, on-board storing and processing of data, cueing of other sensors, and providing alerts. They will enable the widest possible range of collection opportunities and flexibility in emplacement in order to provide wide area persistent surveillance. Sensor technologies specifically applicable to unmanned aerial systems are also required. These sensors need low probability of intercept (LPI) and/or low probability of detection (LPD) communication capabilities to quickly extract large amounts of data from ranges of tens of kilometers.

-- Intel STO-3: Ensure mission-focused situational awareness in urban environments



Develop structure-penetrating sensors capable of detecting and classifying moving and stationary personnel, detecting firearms and explosives, and identifying construction features from standoff range in an urban environment. Urban structures include buildings, basements, sewers and subterranean complexes. Ensure that ISR sensors operate reliably in cluttered environments. These sensors should be able to classify the threat level associated with personnel. Develop the ability to process raw data from structure-penetrating sensors and other intelligence sources into optimum own-course-of-action decisions enabled by data mining and visualization.

-- Intel STO-4: Enhance tag, track, and locate (TTL), biometric, and chemical, Biological, radiological, nuclear, and explosive (CBRNE) detection capabilities[7]

Develop tools, sensors and materials to track any object, vehicle, or person of interest. Tracking should be enabled by standoff biometrics, TTL and by the detection and tracking of associated electronic equipment. Develop taggants that influence one another based on proximity. Develop a capability to sense the presence of conventional explosives as well as Chemical, Biological, Radiological, and Nuclear material. Develop algorithms to translate detections or tracks to actionable intelligence. Develop technologies that provide a means to positively identify bomb makers and enemy threats and then disseminate information to appropriate echelons of command.

-- Intel STO-5: Expose enemy networks, and anticipate and influence their behavior

Develop automated techniques for establishing causality between entities, taking into consideration geo-cultural influences. Develop technology to model enemy decisions and behaviors of interest, and enable their manipulation. Develop techniques to reliably anticipate the actions of irregular actors. Develop algorithms that can translate sensor data and generate automated indications and warnings. Develop ability to continually assess the relative threat level associated with entities and entity aggregates.

-- Intel STO-6: Translate data to combat information at the point of collection

Develop algorithms that can translate raw data to useful information at the point of collection in order to conserve bandwidth. Develop agents that can monitor overall sensor field status and optimize intelligence collection.

-- Intel STO-7: Provide actionable intelligence to tactical units

Develop an intelligent, scalable and non-intrusive knowledge discovery interface that allows a tactical user to harness the power of the local sensor field as well as higher level intelligence. Develop technology to enable tactical ISR to support current operations in near real time. Enhance the ability of Enhanced Company Operations (ECO) and Company-Level Intelligence Cells (CLICs) to support the warfighter. Network warfighters, mobile sensors, and distributed data analysis nodes to enable tactical decision-making.

-- Intel STO-8: Deny enemy use of communications and networks

Develop technologies that enable the denial of selective communications spectra to the enemy. Denial can be through jamming or through the insertion of deceptive or misleading data. In addition, develop technologies that counter attempts to deny our use of the RF spectrum for communications and network operations.

-- Intel STO-10: Investigative forensic technologies and methodologies

Develop the technology to permit the operating forces to perform and apply investigative forensic and pattern analysis techniques in order to track IEDs back to their source.

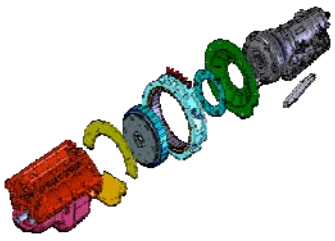
Maneuver

The S&T investment in maneuver is primarily focused in increasing the mobility of ground forces while continuing to ensure they are compatible with our expeditionary role. We are striving to improve the air-mobility of vehicles either through making them internally aircraft transportable or through development of a means to transport them externally from aircraft at high speeds. We continue to focus on fielding a survivable and fuel-efficient family of vehicles, more survivable aviation connectors and improving our ability to protect and insert capabilities at greater distances in reduced times.[8] Our intent is to improve mobility for the entire MAGTF, to include specifically both the mounted and dismounted Marine, enabling unrestricted maneuver across the littoral battle space to include at sea, in the surf zone, over the beach, and ashore.[9]

Essential to unrestricted movement across the battle space is counter explosive hazard technology. The S&T investment of interest to the Marine Corps in counter explosive hazards, including mines and IEDs is focused in two specific areas: detection and neutralization.

***The Vision*: Marines will maneuver from the seabase in a family of high-speed connectors that include amphibious vehicles, tilt-rotor and rotary bladed aircraft, and high-speed surface craft. Once ashore, Marines will have freedom of maneuver either dismounted or utilizing a family of highly mobile and survivable combat vehicles. Marines maneuvering from the seabase will be able to conduct assault breaching of complex obstacles (including minefields) and follow assigned tracks through the shallow water, the surf zone, over the beach, and inland without impediment to maneuver.**

Goal: The focus is to achieve needed operational and tactical mobility in support of Distributed Operations. This includes projecting forces from the seabase, and once ashore, employing vehicles that are significantly more sustainable through Autonomic Logistics and survivable with alternative power systems, a reduced requirement for fuel, along with crew and manpower reductions. Mobility systems will be more reliable with a reduced requirement for routine maintenance and employ autonomic features to integrate functions of crew, vehicle, and weapon system. Dismounted Marines will employ technologies that enhance their performance: in speed, range, and in load bearing capacity. The maneuvering forces will have the ability to detect and neutralize mines and IEDs from sufficient stand-off distance that they do not put the maneuvering force at risk with minimal impact to rate of advance. Once established ashore, MAGTF elements will have the ability to continue to detect, avoid, and neutralize mines in complex terrain including urban environments. Where mines and/or IEDs are detected, the MAGTF commander will have the ability to rapidly apply investigative methodologies to determine source of devices.



-- MVR STO-1: Advanced power plants, drive trains, and suspensions

Develop technologies to improve current vehicle programs and support a new family of vehicles that are lighter in weight and thus

more fuel efficient with onboard exportable power capability, and more capable of being effectively transported by air from the seabase to the shore. Advanced propulsion, drive trains, and suspensions to improve performance over rough terrain are required to enable greater agility enhanced by speed and mobility.

-- MVR STO-2: Advanced materials and survivability technology to enhance the performance and survivability of combat vehicles

Develop technologies to improve the survivability of both current and future tactical and combat vehicles through the use of innovative passive and active technologies. Develop technologies that have better blast and ballistic protection qualities while reducing the overall weight to the vehicle or platform in order to decrease the impact on performance. Where applicable develop technologies that enable threat-specific protection to be readily added to vehicles and platforms as needed for a specific mission or to counter an emerging threat.

-- MVR STO-3: Augmented cognition for combat vehicle crews and operators of maneuver systems

Develop technologies to assess cognitive state and workload of human operators non-invasively and to manage workload of the combat vehicle crew, the vehicle weapon system, and the vehicle IT infrastructure to improve man/machine performance while moving, shooting, and communicating.

-- MVR STO-4: Marine performance enhancements

Develop technologies that provide protective equipment, communications equipment, weapons, ammunition, sensors, and optics for the mounted and dismounted Marine that are multifunctional, lighter, and provide greater capability. Technologies, such as exo-skeletons[10] are needed to enhance the performance of the Marine by improving load carrying capacity and speed and distance of movement.

-- MVR STO-5: Advanced robotic systems for ground combat

Develop technologies to enhance effective and efficient employment of ground robotics. Focus on improving capabilities while reducing training and operating requirements of user Marines. Fully autonomous vehicles are not necessarily the goal. Technologies that enable effective "supervised autonomy" by the Marine user – to include teleoperation, machine vision, obstacle avoidance, convoy following, and the ability to self-navigate pre-planned routes are desired capabilities.

-- MVR STO-6: Explosive hazard detection from the surf zone to inland objectives

Develop the technologies to enable the detection of mines and minefields from the surf zone through to inland objectives[11] for sustained operations ashore. Detection technologies must

encompass a variety of threats including buried and surface laid mines and IEDs. Detection includes both near-field/far-field detection and it will consist of multi-spectral approaches with particular emphasis on detecting the explosive itself, IED precursor materials and other detectable signatures across the IED kill chain.

-- MVR STO-7: Vehicle Design for Marine Usability and Survivability

Define vehicle occupant survivability and human machine interface standards that are based on quantitative metrics and measurable criteria. Develop an abbreviated injury scale for vehicle occupant protection and metrics that are medically based, quantitative, repeatable, and analogous to U.S. automotive industry standards.

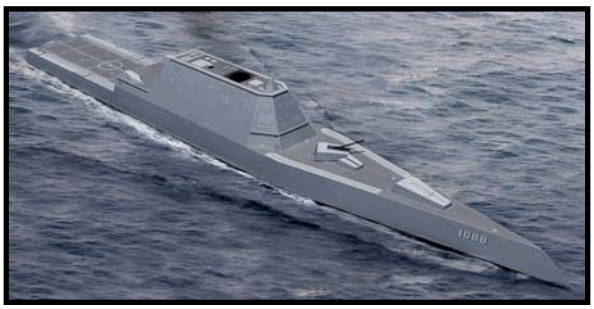
-- MVR STO-8: Mine and IED neutralization

Develop technologies to either neutralize mines and IED's from a safe distance or induce a pre-detonation/deflagration in order to remove the threat from maneuvering forces. These technologies include active and passive countermeasures to devices, energetic neutralization methods to kill devices (igniter blasting caps), and mechanical methods to rapidly clear devices.[12]

Fires

The Fires S&T investment is focused in four areas: (1) targeting and engagement, (2) advanced ammunition, (3) advanced weapons, and (4) energetic materials.

***The Vision**: Marines, capable of being employed in small, distributed units, will locate and decisively engage larger enemy forces by applying timely, reliable, precise, and accurate fires (kinetic and non-kinetic) from a myriad of platforms. Tactical units will be able to operate well beyond conventional parameters of direct fire mutual support. Marines will use integrated, lightweight optics and sensors to see through all battlefield conditions (day, night, low light, and obscuration) and they will use lightweight, organic, manned and unmanned platforms and advanced weapons for the rapid, accurate, effective application of firepower across the full range of military operations. They will also apply non-organic and joint fires optimally. Increased intelligence capabilities delivered by company intelligence cells will generate more potential targets in the future.*



Goal: Fires S&T investments are based upon the premise that Marines, as "soldiers of the sea," are an integral part of the Naval Services. They will remain organized, trained, and equipped to conduct Naval campaigns and operate on and from Naval platforms, or to fight in protracted campaigns ashore; with the expectation of operating in inhospitable conditions against committed and competent foes. The individual Marine is the most formidable weapon on the battlefield and will remain so in the future. Marines will be able to engage enemy formations with scalable air, ground, and maritime capabilities in major contingencies, equally able to employ irregular warfare skills, and capable of transitioning seamlessly between fighting, training, advising, and assisting. Being a persistently engaged, multicapable force, addressing the full range of future contingencies, the Marine Corps will be preventative in approach, leaner in equipment, versatile in capabilities, innovative in mindset, and increasingly reliant on naval deployment. Fires S&T efforts will support the Marines emphasis of speed of execution, agility, and flexibility; and will strike a balance between being heavy enough to sustain expeditionary warfare and light enough to facilitate rapid deployment. As an example, the ability to quickly and accurately locate a target and deliver timely precision fires is a means to increase agility and combat power while at the same time, reducing the logistics required to support the delivery of high volumes of fires necessary to compensate for target location inaccuracies.

-- Fires STO-1: Targeting technologies for faster, more precise engagements, while simplifying fire control tasks

Develop lightweight, durable low-power technologies to enable mounted and dismounted Marines to locate, discriminate, acquire targets, and transmit the information necessary for immediate engagement by direct or indirect, kinetic and non-kinetic fires, at extended ranges, in all weather.[13] Develop technologies to tag, track, and locate targets for possible subsequent detainment or targeting, from stand-off distances.

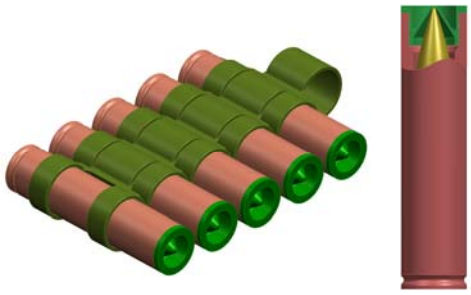
-- Fires STO-2: Integrated lightweight day-night optics

Develop technologies that enable precision target detection, identification and designation by direct fire weapons in all light and weather conditions at the maximum effective range of the weapon system. Technologies must be lightweight, durable, low-power consumers and easy to use. Systems are required for both individual and crew-served infantry weapons.

-- Fires STO-3: Engagement damage assessments

Develop technologies to enable rapid determination of results of combat action (both kinetic and non-kinetic), day and night, through obscurants, for immediate re-targeting or re-engaging.

-- Fires STO-4: More capable, lighter weight ammunition across the spectrum of lethality, with increased reliability, range, precision, and safety.



Develop ammunition technologies for direct and indirect fire weapons, small arms through major caliber; with reduced costs and logistics burden, and increased operating, transportation, and storage safety; and increased shelf life with reduced storage maintenance requirements. Objectives include scalable, modular, and enhanced-effects munitions for decreased collateral damage. Develop technologies for low-cost guided flight control for light, medium, and heavy mortar ammunition to provide flight trajectory shaping and precision fires. Develop technologies for conventional ammunition to enable increased precision and prosecution of tagged suspected hostile individuals from stand-off distances, or stand-off tagging of suspicious vehicles; technologies to see through hardened materials to allow for precise engagement with wall penetrating lethal and anti-materiel munitions. Develop technologies to correct the course of small caliber rounds, including sniper ammunition. Develop technologies for special applications fuses and warheads, to create personnel entry points in reinforced concrete and multiple brick structures, and to defeat advanced armor systems for all classes of ground vehicles, future advanced protection materials including "smart weapon" applications, and future body armor systems. Objectives include ammunition to deliver less than lethal effects on personnel, vehicles, and watercraft; suitable for warning or suppression fires; from service crew served and individual weapons; to enable rapid escalation of force from warning, to non-lethal, to lethal effects.

-- Fires STO-5: Improved propellants and energetic materials.

Develop propellant technologies to increase performance of direct and indirect fire weapons, small arms through major caliber, and to increase safety for munitions rapidly exposed to hot chambers and other adverse environmental conditions. Objectives include developing propellants to increase mortar and other projectile muzzle velocities within chamber pressure design constraints, decreasing propellant weights for various classes of ammunition, and reducing weapons launch signatures. Develop

technologies to increase the performance of explosives for fires applications, to include energetic structural materials to increase munitions blast yields, improving performance, reliability, and safety of safe/arm devices and fuzes of various classes.

-- Fires STO-6: Increased capabilities and reduced weight of all ground combat weapons systems.

Develop technologies for increased range, improved precision, increased responsiveness, improved user ergonomics, and scalability of direct and indirect fire weapons, small arms through major caliber, to decrease weights, costs, and logistics burden, to increase operating, transportation, and storage safety, and to increase weapons systems or components service life extensions.

--Fires STO-7: Technologies that utilize the electromagnetic spectrum to detect, exploit and target adversary systems, equipment, or individuals.

Develop technologies for coherent energy systems that operate within the electromagnetic spectrum.[14] Objectives may include technologies to improve upon existing platforms that utilize the electromagnetic spectrum to provide fully integrated and networked systems in order to target developing and evolving threats to provide the unit commander the ability to control the spectrum at a time and place of his choosing; systems that make maximum use of available bandwidth - ensuring interoperability within joint standards and protocols providing commonality across platforms; coherent high energy systems that are compact, frequency agile, and energy efficient, with effective thermal management means; explosively driven isotropic radiators; technologies that can produce high average power and high peak power for tailored lethality against a variety of targets that are modular and scalable; and technologies to use direct or indirect fire weapons systems to deliver effects other than kinetic munitions, such as small communications devices, software driven and reprogrammable jammers, wireless intrusion devices, or intelligence, surveillance, and reconnaissance (ISR) devices to name a few.

-- Fires STO-8: Sound suppressors for small arms and crew-served weapons

Develop technologies that will enable effective and efficient sound suppression on all weapons in the infantry company – M16A4/M4/M240G/M290/M9. Suppressors must be capable of supporting weapons employment at the sustained rate of fire, be maintainable by the user – to

include mounting/dismounting to the weapon – and shall not appreciably degrade the effectiveness of the projectile. Focus on delivering the same weapon effects while disguising the source of friendly fire to enemy detection. Other anticipated benefits include enabling effective command and control via radios and voice, and long term reductions in hearing loss.

Force Protection

The S&T investment in Protection is focused on individual protection, platform protection, autonomous systems, and non-lethal effects. The investment in individual and platform protection is intended to provide increased survivability across the spectrum of conflict. Protection technologies are needed to reduce the weight while increasing the levels of protection for individuals and platforms. The inclusion of autonomous systems recognizes the advantages of these systems in performing dangerous tasks remotely. In addition, non-lethal effects S&T investment will provide the MAGTF with flexible and scalable options to the use of force.

***The Vision*: Protection for the individual and MAGTF that enables their successful engagement against the threat in both conventional and irregular warfare. Protection is achieved through both non-material and material means focused at countering or defeating targeted enemy capabilities.**

Goal: The focus is on the individual Marine's equipment, platforms and vehicles, and autonomous systems. Marines should be equipped with lighter weight protective clothing and equipment that reduces the individual's optical and heat signature, and improves survivability against the most common threats while minimizing the impact on mission accomplishment. Vehicles and platforms should be designed to minimize the effects of blast – specifically from mines detonating in the vicinity of wheel wells – and with the capability to readily adapt to

threat-specific armor additions. Active defense systems counter the most common threats to vehicles and platforms. Autonomous systems provide tools that reduce the risk to Marines conducting specific tasks to include but not limited to reconnaissance, local security, mine clearing, and EOD. Non-lethal effects will augment, but not replace, lethal weapons and provide escalation of force options to the commander

-- FP STO-1: Technology that provides improved protection for the individual against fragments, projectiles, blast effects, fire, and lasers with reduced weight and impact on ability to perform required functions

Develop technologies that improve the helmet, body armor, and eye protection for the combat Marine against a variety of threats improving comfort and ease of employment while performing combat functions such as using the service weapon in a prone position or with the gas mask. Eye protection – to include optics – is needed to counter the emerging threat of multi-spectral battlefield lasers.

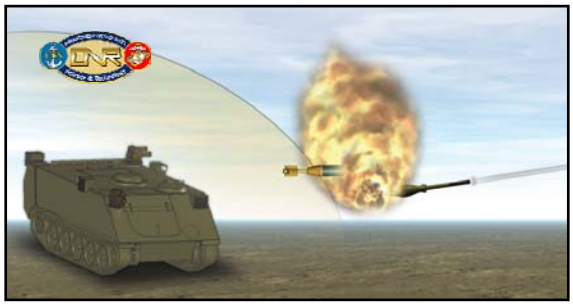
-- FP STO-2: Tactical sensors for persistent force protection surveillance

Develop small, light-weight, autonomous sensors that can capture data with respect to the electromagnetic spectrum, acoustic, seismic, magnetic, chemical, biological, radiological and nuclear properties,[15] in a commanders battlespace that leads to combat information by sensing unique features of entities or their actions, allowing the system to observe, classify, track, record and report information on enemy movements, habits, and intentions. Sensor technologies must be low size, weight and power (SWAP), unattended, hand emplaced, tripod, vehicle, and UAV mounted, and modular within a scalable framework. These sensors must be capable of processing data, cueing other sensors, and providing alerts through common network interfaces. The enabling technologies include nanotechnology, wireless sensor networks, and micro-electromechanical sensor technology.

-- FP STO-3: Mobile sensors for the detection of Low Observable and Low Radar Cross Section (RCS) threats

Focusing on mobility/expeditionary employment as the key driver: Develop modular and scalable technologies that enable near-real time detection and positive combat identification of cruise missiles, UAV's and other low RCS targets on an integrated fire control network of cooperative engagement weapons and sensors.

-- FP STO-4: Mobile weapons systems capable of intercepting low observable/low Radar Cross Section (RCS) threats



Develop technologies that enable expeditionary, maneuverable weapons to intercept the most stressing, low RCS kinematic threats and low observable, low RCS threats, within a keep-out range of approximately 15km. The weapon system must be part of an integrated fire control network of cooperative engagement weapons and sensors. The weapon must resolve the ground based air defense paradox: Robust enough with sufficient range to mitigate the capabilities of adversary low observable, low RCS threats, but light and mobile enough to keep pace with Marine expeditionary maneuver forces.

-- FP STO-5: Counter-bomber detection

Develop technologies that enable dismounted Marines at checkpoints and entry points to detect explosives at sufficient distance to enable effective response to the threat of a suicide bomber. Technologies must be capable of screening multiple individuals rapidly over a wide area and not limited to a single point or isolated individual. Assessment and warning must be near-instantaneous.

--FP STO-6: Identifying threat marksmen

Develop technologies for the mounted and dismounted Marine to detect, locate and report snipers, trained marksmen, and armed irregulars through the entire enemy engagement cycle. Develop technologies that display the range, elevation, and bearing of detected threats on existing networking systems.

Logistics

The S&T investment in logistics is directed toward opportunities where advancements in Science and Technology can enhance (1) asset visibility (2) logistics transport, (3) enhanced self sufficiency (4) maintenance reduction (5) temporary mobile infrastructure, and (6) casualty evacuation.

***The Vision*: Marines of the future will benefit from a precisely tailored level of logistic sustainment from Seabased platforms to rapidly maneuvering forces ashore. Logistic delivery systems of the future will be more responsive and flexible, enabling Marines to out-pace rapidly changing operational scenarios. "Innovative efforts, such as unmanned cargo delivery systems shall be pursued to meet this end."[16] Likewise, delivered logistic commodities will provide more operational value per unit weight, enhancing combat self sufficiency and maneuverability. Finally operational units will benefit from technologies that maximize equipment readiness by minimizing both down-time and maintenance requirements. .**

Goal: The focus is to provide support from a Seabase to the operational echelons ashore down to the tactical level of operations adaptive to the needs of dispersed and highly mobile forces. Reducing the required support wherever practical is an integral part of this goal to specifically include greater energy efficiencies. Towards this end, technologies that provide for enhanced self sufficiency for water, fuel and electrical energy are critical, as are technologies that reduce maintenance and extend the operational readiness of vehicles and equipment. Concepts for temporary shore based infrastructure must be easily transportable and efficiently stored in addition to providing for rapid deployment and reconstitution. The expanded distances associated with dispersed combat units supported from a Seabase will require novel approaches for both casualty stabilization and evacuation.

-- Log STO-1: Logistic commodity inventory/tracking

Develop novel cost-effective RFID tag reading technologies that facilitate autonomous inventory of closed containers. Technologies must be capable of being turned off on demand or being shielded from unauthorized interrogation.

-- Log STO-2: Vehicle readiness tracking

Develop novel sensing technologies that permit individual vehicles to receive the timely logistic support and maintenance necessary to assure operational readiness and prevent mechanical failure.[17]

-- Log STO-3: Optimized delivery planning tools

Develop logistic planning tools that permit new missions to be rapidly planned and ongoing missions to receive flexible logistic support in response to unanticipated changes in the operational tempo.

-- Log STO-4: Air Cargo Transport

Develop cost effective aerial delivery technologies for providing logistic support to highly mobile combat units operating across potentially hostile terrain.[18]

-- Log STO-5: Dismounted Transport

Develop novel weight-effective approaches for small, dispersed, and specifically dismounted units to more effectively transport their own logistic supplies. Develop autonomous and supervised autonomous ground vehicle capable of convoy following as well as the ability to deliver sustainment to tactical units on preplanned routes.[19]

-- Log STO-6: Enhanced self sufficiency for fuel

Develop the portable means to assess the suitability of locally available fuel sources or captured fuel. Technologies must be capable of assessing both the chemical composition of the fuel as well as detecting the presence of the most likely adulterants.

-- Log STO-7: Materials for reduced maintenance

Develop and apply materials technologies to reduce maintenance required for vehicles and machinery. Technologies will emphasize corrosion and wear prevention, and will be applied to specific components that most adversely affect required maintenance intervals or operational readiness.

-- Log STO-8: Enhanced self-sufficiency for water

Develop light weight and energy efficient technologies for small mounted and dismounted units to safely utilize locally available water sources or to scavenge drinking water from environmental sources.

-- Log STO-9: Infrastructure

Develop weight effective technologies for providing small units with alternative tactical mobile electric power sources necessary to support an increasing supply of electronic devices. Provide small units with lightweight technologies for providing low level emergency back-up electric energy. Improve power management, generation, and storage technologies, replacing current batteries with alternatives that are cheaper, environmentally friendly, more compact, and with a longer service life. Develop emerging technologies for energy efficiency application aboard bases and stations as well as forward operating bases. Develop novel concepts for decreasing the weight, increasing the speed of deployment, or expanding the operational versatility of temporary infrastructure necessary to support expeditionary operations ashore. Examples of such temporary infrastructure include bridges, piers, shelters, fortifications, aircraft landing surfaces and electric power grids.

-- LOG STO-10: Energy efficient installations and facilities

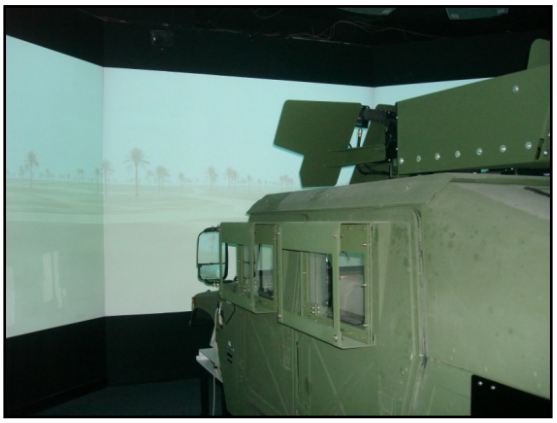
Develop technologies that support the use of alternative and renewable energy sources. Develop power management systems that enable efficient energy storage and distribution within Marine Corps facilities and installations. Specifically, identify technologies that allow Marine Corps installations to operate using net metering.

Training and Education

S&T investment in Training and Education (T&E) seeks to enhance the combat effectiveness of the United States Marine Corps through the development of technology enablers. The DoD Training Transformation Implementation (T2I) Plan addresses the strategic and tactical needs of future training capabilities by OSD, DoD, and Joint Staff. *The Marine Corps Vision and Strategy 2025*, as the Marine Corps principle strategic planning document, addresses the training capability needs in order to prepare for today's fight as well as prepare for the challenges of tomorrow. The MAGTF Training Simulations Division of the United States Marine Corps Training and Education Command is responsible for identification of Marine Corps specific technology needs to enable Training Transformation. The Marine Corps Warfighting

Laboratory acts as the S&T lead to focus the T&E development efforts to address Marine Corps technology gaps. Program Manager for Training Systems is the transition path for acquisition of mature technologies developed through S&T. The Training and Education S&T efforts are an integral part of the process to develop training technologies which will be force multipliers for Marine Corps training events which prepare Marines to win battles in the future.

<u>The Vision:</u> The Marine Corps of today through 2025 requires an unprecedented level of training as it prepares forces to respond to requirements of the Long War and national security requirements both conventional and as yet unknown. Ranges, ammunition, resources, and time are at a premium to meet training requirements. In order to adequately meet these expanding and exceedingly complex training requirements, we will become increasingly more reliant on realistic and effective simulation technologies that support training and education of our Marines and units. The desired end state is improved technology enablers to prepare Marines to win on the battlefield of the future.

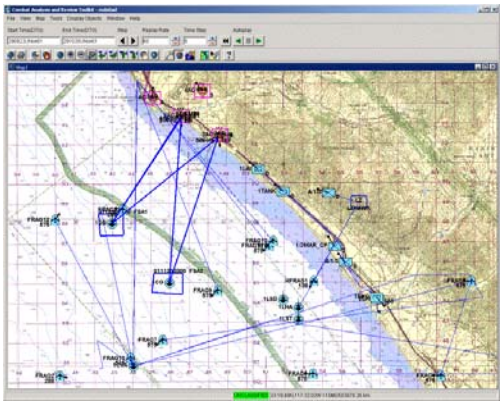


<u>Goal</u>: The training technology focus is the optimization of individual and team performance across the full range of military operations. Technology must support the Marine Corps capability developer's efforts to mitigate DoD Training Transformation (T2) and Marine Corps Vision & Strategy 2025 T&E needs which have no other DOTMLPF solutions.

-- T&E STO-1: Warfighter cognition[20]

Develop tools, systems and training environments/domains which instill and reinforce kinetic and non-kinetic skills necessary to fight on the battlefields of the future. Technology enablers must be provided to support all levels from the individual to the MEF staff and capable of supporting 24-hour operations.

-- T&E STO-2: Learning OPFOR[21]



Develop technologies that address the Warfighter's need to train against an adaptive enemy. Develop Artificial Intelligence (AI) tools that utilize dynamic tactics and reasoning to observe friendly force tactics, exploit weaknesses/repetition and casualties and sway public opinion against friendly force training audience.

-- T&E STO-3: Physics-based library for battlefield effects[22]

Develop accurate and appropriate models of the effects of all Marine Corps ordnance and weapons systems against various weapons platforms, man made features, individuals, crowds, mass formations, and terrain. The goal is to develop a universal library that permits the Marine Corps to model and assess weapons systems effects (catastrophic, social, and political) prior to initiation of hostilities. This will enable both realistic training of Marines and incorporation of Collateral Damage Estimate (CDE) into mission rehearsal.

-- T&E STO-4: Warrior training

Develop flexible training technologies that discern trainee learning styles and then adapt training to optimize the learning experience.

-- T&E STO-5: **Experiential learning technologies and pedagogy**

Develop tools and technologies to enable Marines to train the way they fight. This includes engaging the senses in realistic, challenging, and rapidly reconfigurable scenarios that allow both training and mission rehearsal. The goal is to optimize the application of simulation training across the Live, Virtual, and Constructive (LVC) training and education continuum.

-- T&E STO-6: **High fidelity virtual environment**[23]

Develop technologies that address the warfighter's need to train in a high fidelity physically accurate Synthetic Environment to include accurate geo-specific terrain as well as realistic, culturally accurate and AI-driven entities (friendly, enemy, and civilians).

-- T&E STO-7: **Automated performance assessment**

Develop technologies which allow a user to semi-autonomously create tailored training scenarios based on selected training standards from which the performance is automatically evaluated based on the provided metrics and results are exported to a Marine wide learning management system.

-- T&E STO-8: **Non-kinetic effects simulation**[24]

Develop technologies to provide injections of Political, Military, Economic, Social, Infrastructure and Information (PMESII) non-kinetic effects into operational level staff exercises. This capability is needed to enhance the replication of all elements of current and future operating environments. This capability must not add to the number of support personnel for an event. Currently this aspect is wargamed in a seminar format combined with the kinetic effects of a simulation training exercise.

-- T&E STO-9: **Squad immersive training environment enablers**[25]

Develop the necessary technologies needed to develop an immersive environment that allows for small unit training in realistic environments. In addition to previously mentioned objectives dealing with weapons effects, non-kinetic effects, an improved physical environment and threat behaviors, the Squad Immersive Training Environment will need improved

representation of the array of weapons, to include crew served weapons, and equipment that are organic to the rifle squad. Marines should be able to utilize the full range of functions that the real world piece of equipment possesses.

-- T&E STO-10: **Live virtual constructive training environment enablers**[26]

Develop the capability to simultaneously represent individuals, units, objects and events across live, virtual and constructive training environments. Actions within the live environment will need to be accurately captured and tracked utilizing technologies that are of a minimal impact on the live training. Effects that occur within the virtual and constructive will need to be represented within the live environment.

Escalation of Force

Unlike non-lethal effects that simply focus on single focus technologies, Escalation of Force (EoF) capabilities seeks to embrace the entire continuum of force to enhance the combat effectiveness of the MAGTF by providing flexible and scalable capabilities that will provide an improvement in force protection and force application over current systems. The shifting operational environment is likely to include a greater mix of enemy combatants with non-combatants and an increase in situations where lethal force is undesirable.[27] Operations increasingly occur in urban terrain, and the enemy has shifted to asymmetric, irregular warfare not only to protect themselves, but also to place those who support the United States in jeopardy. With this shift in tactics comes the challenge of identifying and engaging the enemy, while reducing collateral damage and ensuring the safety of noncombatants and friendly forces.[28] EoF capabilities will enhance the Marine's ability to operate in a fluid asymmetric/irregular threat environment by providing improved technologies that are applicable to force protection and force application and that are flexible and scalable from less lethal to lethal -- that is, capabilities that address the entire continuum of force.[29]

<u>The Vision:</u> The S&T investment in EoF is intended to develop capabilities to augment, but not replace, lethal weapons. EoF Capabilities will provide the MAGTF with flexible and scalable options that permit the minimum application of force necessary to achieve desired effects, while minimizing collateral damage and casualties to noncombatants. EoF capabilities that warn, deter and dissuade noncombatants in current and future

mission are essential characteristics of EoF capabilities. EoF Capabilities will enable Marines to achieve this goal while maintaining a high level of force protection.

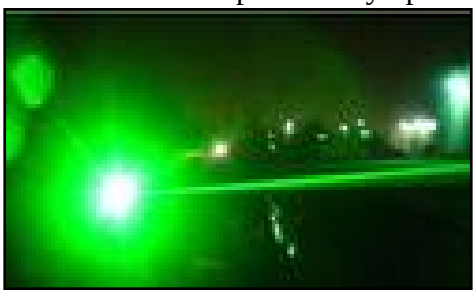
Goal: The focus is on providing operational EoF capabilities for use during situations found primarily, but not exclusively, while operating under restricted Rules of Engagement (ROE) and in environments where the ratio of noncombatants to combatants is high. EoF capabilities are needed in situations where the use of lethal weapons is limited, where threats are unclear, and where collateral damage is a concern, but they must not inhibit mission accomplishment or the use of lethal force when required. The solutions needed to accomplish several different tasks that support MAGTF missions, especially during Phases 4 and 5 of the Continuum of Operations. The Marine Corps needs options to generate effects that immediately neutralize or incapacitate targets. EoF capabilities that warn, deter, and dissuade noncombatants in current and future missions are an essential characteristic of required capabilities. EoF capabilities will provide a full range of lethal and non-lethal effects to protect personnel and materiel through active and passive measures in a dynamic and evolving security environment.

-- EoF STO-1: EoF technologies to warn, deny, move, disable and suppress individuals (counter-personnel).

Develop EoF technologies (kinetic and non-kinetic) to warn, deny, move, disable, and suppress individuals or multiple personnel through precision and area engagements that minimize the risk of significant injury and collateral damage, that produce reversible effects, and that maximize stand-off distance. Target engagements will focus on locations where the application of lethal fires could be counterproductive to US objectives and strategic goals, and where the threat is irregular and unclear (i.e., environments with a high non-combatant to combatant ratio).[30] Develop technologies that are suitable for expeditionary operations and that utilize low energy directed energy techniques, and coherent and incoherent light at various optical frequencies for degrading enemy personnel techniques. Develop directed energy technologies that generate terahertz, millimeter, and microwave electromagnetic radiation at high average and/or peak power. Radio Frequency sources should be made frequency agile and should strive for compactness, energy efficiency, and effective thermal management.[31] In addition, develop technologies that enable scalable directed-energy effects[32] that can provide weapon systems that can deliver non-lethal or lethal effects (scalable from lethal to less than lethal). Both technology development and bio-effects research are required concurrently.

-- EoF STO-2: EoF technologies to stop and/or disable vehicles and vessels (counter-materiel).

Develop EoF technologies (kinetic and non-kinetic) to enhance counter-materiel capabilities to stop and/or disable vehicles and vessels through precision and area engagements that minimize the risk of significant injury and collateral damage, that produce reversible effects, that are suitable for expeditionary operations, and that maximize stand-off distance. Target engagements will focus on locations where the application of lethal fires could be counterproductive to US objectives and strategic goals, and where the threat is irregular and unclear (i.e., environments with a high non-combatant to combatant ratio).[33]



-- EoF STO-3: Communicate with indigenous personnel

Develop technologies that provide a portable capability to translate from English to the local language and the reverse, using audio, visual, and written forms. Develop technologies that allow languages and multiple dialects to be selected, documents to be scanned and translated, and audio output to be amplified to support broadcast announcements. Develop technologies that do not depend on consistent tone, volume, or perfect enunciation, but that do enable direct near-real-time language translation into recognizable electronic speech.

-- EoF STO-4: Clear a space

Develop technologies that provide a less lethal alternative to kinetic/blast weapons for employment in urban operations to clear spaces, facilities, or compartments, without the need for Marines to enter. Target engagements will focus on locations where the application of lethal fires and/or unintended collateral damage could be counterproductive to US objectives and strategic goals, and where the threat is irregular and unclear (i.e., environments with a high non-combatant to combatant ratio). Develop technologies that also permit the detection of personnel inside spaces without the need for Marines to enter or the need to pre-emplace detection systems.[34]

Irregular Warfare

Since its inception, the Marine Corps has been involved in what we now associate as Irregular Warfare (IW), and currently has a very experienced and mature force capable of operating in the IW environment. However, the complex operational environment of the future requires that these current skills and capabilities will continually need to be enhanced to keep up with an ever-adaptive adversary, and an ever-changing environment.

Consistent with the dynamic nature of the operating environment, the training and education of Marines are continuously reviewed, validated, and adjusted to incorporate lessons learned, based upon dynamic adversarial tactics. Understanding that the successes or failures of winning in an IW environment is all about understanding the operational environment and honing our training and skills to counter the "threat," technologies currently on-the-shelf or under development need to be applied to better enable Marines to operate effectively in what will remain a complex environment.

The Vision: ***The S&T investment in Irregular Warfare is intended to identify and develop those potential technological capabilities that can enhance the mission success and increase the survivability of Marines in the IW environment, through training, education and superior tactical capabilities on the future battlefield.***

Goal: Irregular Warfare is focused on influencing the relevant populations and Marines at every level will require improved operational analysis and reachback capabilities for use during all phases of an operation. Marines need tools to enable them to rapidly assess the "human terrain" and then assess, problem solve, and implement effectively both Security Force Assistance (SFA) and Stabilization Operations. IW S&T solutions are intended to rapidly bridge the gap in professional education and training that would otherwise have only been filled by PhDs, city planners, and cultural experts. In addition, Marines require the capability to achieve and maintain "language proficiency and cultural intelligence to prepare forces for the expanded interaction with local populations."[35]

-- IW STO-1: Crowd scanning systems

Develop a sensor system capable of identifying individuals of interest that could pose threats. The system should be individually portable capable of full integration into the ensemble of individual Marines through the use of helmet cameras or similar sensors to collect biometrically relevant data and then transmit the data to where it can be assessed in near real time. The system must have a feedback mechanism that will

provide an "alert" to the affected Marines. The system is needed specifically to identify any person-of-interest within a crowd, approaching a checkpoint, etc. that requires closer inspection but ideally would be sufficiently portable to be used by patrolling dismounted Marines. Threat detection beyond 30 meters is desirable. Develop the means to integrate the detection and alert system with other ground sensors as part of an integrated tag, track, and locate effort.

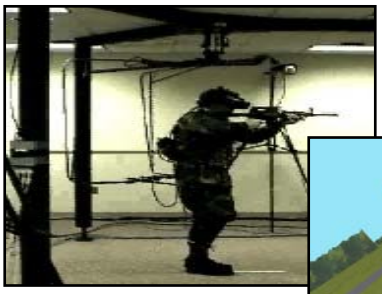
-- IW STO-2: Visual translator system

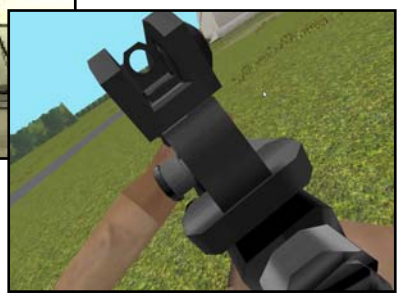
Develop a technology capable of scanning street signs or other forms of written expression and then providing a near real time translation or graphical depiction.

-- IW STO-3: Reachback tool for civil military operations

Develop technology that enables engineers specifically to conduct basic troubleshooting for essential services with schematics and diagrams to assist personnel in reconstruction assessment and emergency repairs. Included should be translations of instructions in specific target languages. Goal is to rapidly provide instructions and supporting documentation to permit local construction and engineer organizations to do the work themselves.

-- IW STO-4: Indigenous weapons training systems





Develop a deployable, low maintenance, training system to assist Marine Security Force Assistance (SFA) teams with training host nations security forces on host nation's weapons (i.e., AKs and SKS rather than U.S. weapon systems such as M16/M4/M9s). Ensure open architecture that not only permits rapid adaptation to any available weapon system but also protocols that enable technology transfer to partner nations and operation on indigenous display technology.

-- IW STO-5: Ship identification and reference tool

Develop a tool that will enable rapid classification of ships and coastal vessels with the ability to rapidly call up schematics and ship blueprints to enable Visit Board Search and Seizure (VBSS) teams to rapidly identify ships and boats by class and then provide a blueprint to guide in the conduct of the search. Develop technology that enables the crew of the parent ship to track the VBSS team's movement within the vessel and enable navigation through the passageways through the use of inertial navigation replacing "pacecounts" or electronic "breadcrumbs. Ensure compatibility with NORAD/USN Maritime Domain Awareness initiatives.

-- IW STO-6: Cultural and language proficiency tools

Develop language and cultural learning packages to support the Marine Corps area specialization program enabling Marines to improve as well as maintain language proficiency while simultaneously expanding their cultural knowledge and effectiveness. Technologies must be flexible and capable of broad application on both military information technology as well as common commercial platforms such as MP3/iPod devices to provide maximum opportunities for their use.

ANNEX A: Seabasing

The sea base is a set of capabilities. Its components – particularly the Maritime Prepositioning Group (MPG) and/or an Amphibious Force (AF) – must be able to support and sustain Naval and Joint forces throughout the range of military operations. Unlike previous military operations with their reliance on land-based infrastructure, the seabasing concept[36] (the sea base in action) calls for Closing, Assembling, Employing, Sustaining, and Reconstituting (CAESR) the force as much as possible from the sea base.

<u>The Vision:</u> Now, more than ever, as we return to our "expeditionary roots" we maintain a tremendous leverage by seabasing and retain our ability to sustain the fighting force from the sea in environments of "anti-access and denial constraints." As such, in "Strategy and Vision 2025" the commandant of the Marine Corps includes naval operations in each of his four methods by which we will remain the Nation's force in readiness, well into the future. Aside from projecting power and minimizing the ashore footprint, he has stated in his objectives that, "we will achieve a robust capability to support joint operations ashore." And stated that, "the ability to conduct at-sea transfer of resources, for both ship-to-ship and ship-to-shore purposes, is a key enabler for deploying, employing, and sustaining joint forces from the sea."[37]

<u>Goal: Within the CAESR construct, Marine Corps' priorities for Seabasing capability development are to do the following:</u>

a. <u>Arrival and Assembly</u>. Develop and refine the Tactics, Techniques, and Procedures; systems; and processes needed to support rapid integration of Flow-in-Echelon forces with forward deployed assets of the 2015 MEB. This priority encompasses the reception, integration and movement (inter/intra-ship) of forces, and the preparation of force assets for onward movement.

b. <u>Sustainment</u>. Develop capabilities to sustain the 2015 MEB from the sea base. Included in these priorities are; asset visibility, automated and manual material handling, advanced packaging methods, and selective offload of supplies and equipment.

c. <u>Personnel and Equipment Transfer</u>. Develop interfaces allowing at-sea transfers of MAGTF personnel and equipment between MPF (F) platforms, ships of the ESG and CLF, lighterage, and other connectors. This priority encompasses; interface ramp technologies, mobile landing platforms, lightweight modular causeways and passenger transfer systems.

d. <u>Cargo/Vehicle Handling and Stowage</u>. Develop systems that enhance the movement, stowage (indexing) and restraint of cargo, vehicles, and equipment. Near-term emphasis should be placed on cargo/vehicle restraint systems, and container handling technologies (including the Shipboard Selective Access and Retrieval System).

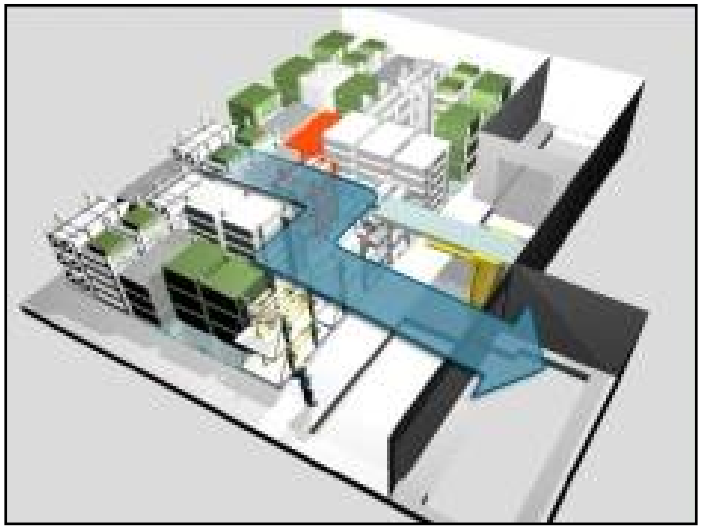
Marine Corps Seabasing Science and Technology Objectives (STOs) emphasize development of the key enabling technologies needed to develop the capabilities and meet the priorities outlined. Most of these technologies are the responsibility of the Navy, but as a principal beneficiary of Seabasing capability development it is the Marine Corps' responsibility to advise the Navy on our Seabasing technology development needs. These STOs outlined below are complementary to the naval objectives provided in Annex A of this plan and are also included in the Naval S&T Strategic Plan.

-- SEA-STO-1: Underway replenishment

Develop an Underway Replenishment (UNREP) system capable of transferring fuel, ammunition, spare parts, heavy bulk sustainment, and their associated containers between ships, vessels, and craft up to Sea State 4. Without this capability, the sea base and naval ships cannot maintain a continuous forward presence at-sea. Included in this STO are alongside Connected Replenishment (CONREP) and Vertical Replenishment (VERTREP) capabilities.

-- SEA –STO-2: Improved internal cargo handling

Develop Strike-Up/Strike-Down (SUSD) techniques and systems that automate the movement of cargo and weapons from the shipboard on-load point to stowage spaces (strike-down), and from stowage to the offload point for transfer to another ship or to shore (strike-up). The sea base must be able to receive, store, track, selectively retrieve, and transport loads in common, advanced packaging. Loads must be reconfigurable for deployment within the sea base or to the shore in configurations compatible for ground or air transport.



-- SEA-STO-3: Selective Offload of Prepositioning Afloat

Develop a selective offload capability that facilitates sea based operations independent of APODs and SPODs within the JOA. The sea base must be able to support up to two brigade-sized forces ashore for extended periods of time. In addition to the selective offload of vehicles, the sea base must be capable of on-demand selective access, retrieval, and offload of sustainment.

-- SEA-STO-4: Joint Logistics In-Transit Visibility/Total Asset Visibility

Develop sea base logistics data systems capable of providing users – afloat and ashore – with timely and accurate information on the location, movement, status, and identity of units, personnel, equipment, materiel, and supplies. The ability to locate, move, track, and transship a variety of cargo from CONUS through an advanced base, to a sea base, between ships at sea, and to forces ashore in common packaging is critical to efficient and effective sea based operations.

-- SEA-STO-5: Seabased Maintenance

Develop technologies that facilitate seabased maintenance for both aviation and ground combat equipment. A sea based maintenance capability is essential for maintaining a high operational tempo and reconstituting combat power.

-- SEA-STO-6: Joint Intermodal Packaging

Develop Joint intermodal packaging, using common end-to-end packaging concepts and containers, to ensure that supplies will not have to be repackaged as they travel through commercial or government transportation systems—through the sea base—to end users ashore.

-- SEA-STO-7: Time Critical Resupply

Develop technologies to adequately support and sustain all sea based supply requirements between advance bases, the sea base, and forces ashore. A critical component in the sea base's ability to meet time critical resupply requirements is air and surface connector interoperability with sea base nodes. Included in this STO are aircraft exhaust temperature and flight deck warping, ship-board potable water production in brown-water environments, and cargo UAV capabilities.

-- SEA-STO-8: Open Ocean Interface and Transfer

Develop an open ocean interface and transfer capability between ships and vessels of the sea base at up to Sea State 4. Potential technology investment areas that support open ocean interfaces and transfers include:

1) Dynamic positioning systems.
2) Advanced fendering or mooring techniques and approaches.
3) Advances in ship heading control systems, including wave/wind prediction.
4) Side-port, ship-to-ship vehicle ramps.
5) Small ship to large ship interface methods.
6) Ship-to-ship passenger transfer.

ANNEX B: Aviation

Marine Aviation is an integrated and essential component of the Marine Air-Ground Task Force (MAGTF), supporting and sustaining Naval and Joint Forces throughout the range of military operations. Aviation resources must be available to the MAGTF/Joint Force Commander regardless of the operational scenario, austerity of engagement, or level of lethality. Due to the complexity and expense normally associated with aviation combat and support systems, it is necessary to include extensibility/upgradeability as a key aspect of all components to ensure future utility regardless of the threat or operational environment.

<u>The Vision:</u> Now, more than ever, as we execute the Commandant's "Vision and Strategy 2025" in complex, hybrid environments of the future, we must be well postured to remain the Nation's force in readiness, regardless of the operational context. To this end, the Aviation vision is for a network-enabled and digitally-interoperable expeditionary aviation combat element postured to execute responsive, persistent, lethal and adaptive full-spectrum operations as directed by the MAGTF or Joint Force Commander.

1. <u>Aviation S&T Strategic Guidance</u>. This Annex serves to articulate Marine Corps unique S&T needs to those agencies devoted to Aviation S&T priorities. Aviation focal points include both S&T Program Opportunities and Legacy S&T Investment Category Priorities.

a. <u>Key Program Challenges.</u> These are the major Aviation program areas that have opportunity for high-payoff S&T investments:

(1) Data links and Information/Capability Management Networks
(2) Heavy Lift Replacement (HLR)
(3) Electronic Warfare (EW)
(4) Unmanned Aerial Systems (UAS) and associated payloads

b. <u>Legacy (Rotorcraft) Investment Category Priorities.</u> These are prioritized categories in terms of current aviation-related S&T technology modernization/transition/insertion as well as future aviation programs.

(1) Survivability/Safety: Improvement in the ability to avoid detection, tracking and engagement in a complex threat environment and survive hit/crash.

(2) Battlefield situational awareness: Improvement in the ability to know and comprehend the location, intent, and actions of blue/red forces, non-combatants, environment condition, terrain, and obstacles in the area of operational responsibility. This includes increased situational awareness for embarked Marines while maneuvering.

(3) Lethality: Improvement in the ability to precisely deliver a spectrum of intended effects (lethal or non-lethal).

(4) Battle Command: Improvement in the ability of the commander to decide on a course of action and execute command measured in response time.

(5) Affordability: Reduction in development, acquisition, operating and support cost while maintaining or increasing capability.

(6) Supportability/Maintainability: Improvement in reliability, availability and maintainability.

(7) Training: The efficiency with which commanders/staff, pilots, operators and maintainers are initially and continuously trained to proficiency.

(8) Footprint: Reduction in the weight and volume of the personnel, materiel, equipment and supplies that support an aerial system and must be moved.

(9) Deployability: Reduction in the time, effort, and support systems to prepare, transport, and restore a force capability.

(10) Mobility: The ability to responsively maneuver and transport troops, supplies and equipment on the battlefield in complex terrains/sea states.

2. Aviation S&T Relationships. Relationships with the following agencies are essential in order for the Marine Corps S&T IPT to ensure visibility on adequate Aviation leverages, sharing unique leverage opportunities, and ensuring an overall balanced Marine Corps Aviation S&T investment.

a. *Naval Aviation Enterprise (NAE)*. The leadership of the NAE publishes a biennial S&T Plan[38] and its own STOs[39] to provide guidance to the NAE. Marine Corps aviation is dependent upon the NAE for much of its S&T investment and coordinates as appropriate for development efforts of mutual Navy and Marine Corps benefit.

b. *Office of Naval Research (ONR) and the Naval Research Laboratory (NRL).* Achieved primarily via the Marine Corps S&T IPT, but also through a direct relationship with ONR and NRL.

c. *Air Force Research Lab (AFRL) and Army Research Lab (ARL).* Key S&T partners providing insight into cross service opportunities for collaboration across a wide variety of platforms, programs, and interests.

d. *Defense Advanced Research Projects Agency (DARPA)*. Provides cutting edge research applicable to all of DoD with potentially large payoffs for Marine Aviation.

e. *ARMDEC*. U.S. Army Research, Development and Engineering Command: responsible, by charter, for rotorcraft S&T. This is a key relationship as rotorcraft S&T investment has been minimal for over a decade.

3. Marine Corps specific Aviation STOs:

-- AVN STO-1: Collaborative networking

Develop technologies that facilitate and provide for a network-enabled and digitally-interoperable expeditionary aviation combat element postured to execute responsive, persistent, lethal and adaptive full-spectrum operations.

-- AVN STO-2: Advanced electronic warfare (EW) systems

Develop technologies that are compatible with Marine Corps follow-on Electronic Attack (EA) platforms as the platform requirements are refined. Develop multi-function, transceiver arrays that enable future EW as well as provides adequate bandwidth, SIGINT and ISR and Next Generation Jammer technologies. Software Reprogrammable Payload (SRP) is a single common payload module that is flexible and reconfigurable to support simultaneous missions and applications making maximum use of available bandwidth and ensuring interoperability within joint standards and protocols providing commonality across platforms. Collaborative On-line Reconnaissance Provider Operationally Responsive Attack Link (CORPORAL) is a Joint Capabilities Technology Demonstration that Provides "on-demand" collaborative situational awareness (NTISR) & kinetic and non-kinetic fires to the small unit's target area of interest. It consists of plug-and-play, software reprogrammable, scalable, IP-based, and open-architecture non-kinetic fires solutions and will outpace traditional point solutions, accommodate existing legacy systems, and provide a bridge to future operational systems, enabling machine-to-machine collaboration and coordination.

-- AVN STO-3: Sand and dust-penetrating radar, providing precision (landing quality) navigation video in brownout and dust-out visibility conditions

Develop technologies that enable passive obstacle detection at range (i.e., uncharted wires/cables) and enables precision support of distributed operations in unprepared landing zones for current rotary wing and tilt rotor aircraft, as well as supporting technology transition into future UAS. Develop complementary technologies to precision quality navigation in brown-out/dust-out that enables precise, landing quality, non-visual air and groundspeed reference.

-- AVN STO-4: Command and control (C2) data fusion and networking

Develop technologies to support data fusion to improve sensor tracking of tactical aircraft and UASs as well as the fusing of data from the various ground and intelligence system employed by the MAGTF. The most significant challenge for Aviation C2 is the quest for data fusion. The requirement statement in the CAC2S CPD describes data fusion as fusing data from real time sensors/ near real time TADILs and non-real time data components to deliver an adaptive situational display. Develop a robust data network established with common databases that push near-real time updates to C2 operators and aircraft. Overcome security and IA requirements with multiple data standards and security levels. Develop a single system that can interface with both current ground C2 and intelligence systems and has communication channels with adequate capacity to transmit and receive terabytes worth of data.

-- AVN STO-5: Standardized force tracking system

Develop technologies that provide 100% assured, covert, real-time identification of friendly forces for fratricide avoidance as well as battlefield coordination, maneuver deconfliction, command SA, future re-supply/CASEVAC etc during future distributed operations. Incorporate tracking technologies applicable to red-force/HVT (classified).

-- AVN STO-6: Group 4 (Tier III) unmanned aircraft systems (UAS)

Develop an expeditionary, all-weather, high endurance, multi-mission UAS capable of operating from austere locations and providing networked, interoperable systems to enhance the MAGTF and Joint Force Commander's battle-space awareness. Further refinement and development of Unmanned System Interoperability Profiles (USIP) standards for aircraft configuration, payload interfaces, data transmission, and UAS control will enable seamless integration between manned/unmanned systems and command and control networks. Advancements in standard interfaces will allow for interchangeable, mission-tailored payloads such as Electro-optical/Infrared, Electronic Warfare, Signals Intelligence, Synthetic Aperture Radars, Communications Relay, Laser Designators, Wide Area Scan, Ground Moving Target Indicators, and Network Enablers.

-- AVN STO-7: **Advanced multi-function EW transceiver**

Leverage Next Generation Jammer (NGJ) technologies to develop capabilities compatible with Marine Corps follow-on EW concepts (i.e. system-of-systems distributed EW, including low observable systems) as the system requirements are refined. Multi-function transceiver arrays potentially enables future EW as well as increasing bandwidth access, SIGINT and ISR capabilities.

-- AVN STO-8: Ground based C2 and surveillance systems

The concept of active aperture array is critically dependent on the availability of compact and minimum weight, low consumption and high reliability Transmit/Receive (T/R) modules. Develop technologies that provide the thermal margins required to meet mission radar performance for the T/R modules using of state of the art, air-cooled technology. Develop manufacturing techniques that can produce high quality, micro-miniature RF circuits (T/R

modules) that are not susceptible to stress and cracking during production. Develop technologies that support the calibration of an ambient air-cooled Active Electronically Scanned Array (AESA).

-- AVN STO-9: Advanced laser systems suitable for countermeasure, sensor, and attack applications

Develop laser enabling technologies including multi-scan mirrors, high power/high efficiency optical amplifiers and switches, dual/multi band laser systems, lightweight open and closed loop IRCM systems, and high duty cycle systems. Resulting technologies must be applicable to both rotary and fixed wing air vehicles and provide exceptional reliability. Systems developed should interoperate with existing air-vehicle subsystems with minimal integration effort and provide countermeasure, sensor and attack capabilities.

-- AVN STO-10: Scalable, light weight, interference cancellation system and adaptive/cognitive radio technologies for both co-situated RF emitters and RF saturated environments to eliminate VHF, UHF, SATCOM RF interference between multiple radio and electronic attack systems.

Develop low-cost interference cancellation technologies and adaptive/cognitive radio systems to enable assured communications and information distribution for emerging platforms and systems as well as technology transition for legacy platforms that suffer communications degradation with multiple communications systems or jamming.

-- AVN STO-11: Net-enabled weapons

Develop technologies that enable aviation ordnance to rapidly join the battlefield network in order to allow terminal control, ISR, and Bomb Damage Assessment (BDA). Additionally, develop small form factor jammers (i.e. Digital RF Memory (DRFM) systems) capable of being utilized in ordnance, artillery, expendables.

-- AVN STO-12: Cargo UAS

Develop advanced UAS vertical lift technologies in order to provide force sustainment to multiple company-level operations over a widely dispersed area. Explore autonomous and semi-autonomous Line of Sight (LOS) and Beyond Line of Sight (BLOS) UAS control in remote deployed environments to facilitate navigation and cargo delivery during 24/7 operations. Cargo UAS platforms are required to operate at high density altitudes, delivering multiple in-stride cargo drops, over round-trip distances with a threshold of 150 nautical miles and an objective of 900 nautical miles, reducing the number of ground transport delivered items

-- AVN STO-13: UAS universal ground control station (UGCS)

Develop UAS Universal Ground Control Station (UGCS) with Type I encrypted Tactical Common Digital Link (TCDL) capable of controlling USMC and Joint UAS Family of Systems. Advancement in UGCS interoperability enables ground control of current and future UAS platforms to provide increased operational capability and scalable UAS options to the war fighter. It will also facilitate the rapid development and acquisition of system compatible UAS platforms.

-- AVN STO-14: Active kinetic and non-kinetic aircraft self-protection

Develop technologies such as high energy liquid and fiber laser systems and continued investment in technologies which enabled systems such as Tactical Aircraft Directable Infrared Countermeasures (DIRCM). Develop technologies that enable "unlimited magazine" self-protect capabilities against both IR SAMs and RPGs while reducing requirement for magazine (i.e. flares). Additionally investigate Electromagnetic Pulse (EMP) and High Power Radio Frequency (HPRF) technologies development for both offensive and defensive lethal and non-lethal effects.

-- AVN STO-15: Radio frequency (RF) countermeasure, decoy, and expendables systems

Develop technologies related to RF countermeasures applicable to fixed and rotary wing aircraft. Systems include towed decoys, released/launched decoys, RF jamming systems, and RF expendables. Develop both active and passive RF systems that contribute to, and collaborate with, the EW system-of-systems construct in an EW battle-managed environment as well as provide offensive RF capabilities. Develop technologies that assure that RF systems can interoperate with "blue" force systems in all domains and environments.

-- AVN STO-16: Advanced rotor/prop technologies for performance across wider envelope[40]

Develop advanced technologies for rotors/props as components of assault support propulsion as well as tactical UAVs. As rotorcraft/helicopters (MV-22/VUAV) requirements grow in terms of hover load and harsh environments (heat/dust/high altitude), as well as top-end speed (i.e. MV-22 escort), advanced rotor performance enhancement (dynamic blade shaping) will garner performance as well as efficiency (fuel/load savings). Develop V-22 capability enhancements to sustain performance KPPs and improve high altitude operations. V-22 design is based on tropical day at 3000 ft/91.5º F. OEF and other potential deployment locations require lift well beyond this ambient pressure/temperature. Develop technology that can increase vertical lift by at least 2000 lbs, increase operational radius by at least 40 nm, and preserve 10,000 lb load KPP

-- AVN STO-17: Small form factor, lightweight expeditionary ordnance for fixed and rotary wing aircraft

Develop technology supporting a family of small, lightweight expeditionary ordnance for both fixed and rotary wing aircraft. Given the logistic challenges of transporting aviation ordnance to expeditionary Forward Operating Bases (FOBs), as seen in Iraq and Afghanistan, it is necessary to have small, lightweight ordnance available that can be easily transported overland or by aircraft (*e.g.* KC-130) to austere sites rapidly and then loaded quickly and easily by minimal personnel. Small form factor ordnance, on the order of 50-250 lbs explosive equivalent, will further increase number of weapons fixed and rotary wing aircraft can deliver during a single sortie while both scaling effects and minimizing collateral damage. Develop technologies that can enable basic ordnance to have a variety of fusing, guidance and propelling packages thereby increasing functionality of this family of ordnance.

-- AVN STO-18: Low collateral damage/low energetic weapons

Develop technology supporting a family of Low Collateral Damage/Low Energetic weapons. Existing methods of obtaining Low Collateral Damage munitions include reducing the amount of explosive filler of existing weapons. Develop technologies to improve accuracy thereby reducing the risk of collateral damage when an appropriate lethality warhead and fuse are applied. Develop technologies that ensure weapon fusing and weapon yield is electable from within the cockpit.

-- AVN STO-19: Cost effective mass memory (terabytes)

Develop improvements for Digital Map and other avionics systems capable of higher speed data transfer, as well as sensor data/information storage, retrieval, and dissemination compatible with airborne and shipboard environmental conditions. Develop technologies that enable autonomous operations with comprehensive information onboard. Information storage onboard autonomous platforms reduce the risk in distributed and net-centric operations against an EW-capable adversary where link information is potentially denied.

-- AVN STO-20: **Distributed networking of aviation simulators.**

Develop simulators and technologies to enable Aviation Marines to train the way they fight. This includes engaging the senses in realistic, challenging, and rapidly reconfigurable scenarios which allows scenario-based training and mission rehearsal. The goal is to optimize the application of simulation training across the Live, Virtual, and Constructive (LVC) training construct throughout Marine Aviation.

-- AVN STO-21: **Multi-function, low-drag VHF, UHF, and SATCOM (broadband) antenna**

Develop technologies that enable reduced airframe antennae and reduced airframe signature, including conformal arrays and active elements, as communications and data link requirements grow, while allowing communications growth without additional apertures.

-- AVN STO-22: Composite materials in expeditionary environments

Develop technologies for health monitoring of composite structures enabling "condition based maintenance" and "predictive failure" of composite structures on aircraft in order to reduce time in Depot Level Maintenance facilities as well as reducing NDI inspections. The increased use of composite structures requires an enhanced capability to rapidly make repairs to these structures in all environmental conditions (heat, cold, sand, humid, etc.) requires the development

-- AVN STO-23: Lightweight De-ice/Anti-ice capability for aircraft

Develop technologies to provide a lightweight all de-ice/anti-ice capability for both rotor blades and fuselage that reduces both weight and electrical power requirements. Current de-ice/anti-ice capabilities are heavy due to power requirements for heating and wiring.

-- AVN STO-24: **Variable-speed air refueling drogue**

Develop technologies that enable refueling drogues to refuel fast tactical aircraft as well as slower rotorcraft.

-- AVN STO-25: Aviation technologies that increase the capacity of aviation assets

Develop technologies for rotary wing and heavy-lift applications to increase survivability and decrease the weight of aircraft in order to increase performance of rotary wing transport aircraft. Development of unmanned alternatives to manned helicopters[41] for the delivery of logistics support with reduced risk to manned aircraft is also desired.

ANNEX C: Naval Medicine and Human Performance

Naval Medicine supports and enhances the expeditionary warfare capability of the United States Marine Corps through the development and rapid adoption of relevant enabling technologies. Recognized and anticipated technology capability gaps are identified not only through the systematic, ongoing warfighter's review of recent and current Marine Corps operations, but also through strategic future planning designed to fully support the *Commandant's Marine Corps Vision & Strategy 2025;* a vision of an unparalleled expeditionary warfighting force that is fast, lightweight and lethal. Naval Medicine science and technology (S&T) research in support of that vision will complement (not duplicate) the medical research efforts of the other Services, those supporting the militaries of other nations, and those conducted within the private sector. In addition, medical S & T initiatives will be designed for full integration into the USMC S&T Strategic Plan.

The Vision: ***Using the Marine Corps Vision and Strategy 2025, Naval Medicine technologies will support and realize operational concepts focused on defeating Hybrid threats and challenges, enhancing the MAGTF's flexibility, agility, and adaptability, enabling Marines to quickly analyze, clearly decide, and decisively act, thus increasing the ability of the rifle company to conduct the full range of missions. Medical technologies will clearly demonstrate support for one or more of the following operational imperatives:***

- ***Seabasing***
- ***Persistent forward presence and engagement***
- ***Agile and adaptable forces***
- ***Remaining multi-capable across the range of military operations (ROMO)***

Goal: The Naval Medicine S &T planning process will identify and prioritize relevant capability gaps, requirements and emergent needs for the next-generation of Force Health Protection and Expeditionary Medicine. The process owners will both develop and champion a high-level investment strategy in support of Naval Medicine and Marine Corps strategic goals for research of operational readiness, military health care, and health promotion.

-- Med STO-1: Casualty management capabilities

Develop technologies to improve immediate point of injury (first responder) care, enhance life-saving forward resuscitative care, ensure appropriate theater hospitalization and optimize en route evacuation care to definitive tertiary care for casualties of the future battlefield.

-- Med STO-2: Human performance enhancement capabilities

Leverage existing and/or create new technologies to reduce warfighter fatigue, optimize human-systems integration, enhance warfighter sensory, cognitive, and motor capabilities, enhance mental resilience to stress, improve warfighter learning, communication, and decision-making skills, enhance physiological capability and maintain warfighter abilities in austere or stressing environments to provide a healthy and fit force.

-- Med STO-3: Fatigue management

Develop technologies that enable both the individual and the commander to detect when a Marine is becoming fatigued to the point where it affects cognitive functioning, decision making ability, or other aspects of operational performance. Detection capability must be specific to the individual and adaptable to operational field ensembles for dismounted operations. Develop the capability for a commander to safely and effectively manage sleep as he would food, fuel, ammunition, or other essential logistical supplies. This capability may include pharmacological agents for initiating/maintaining sleep provided their effects are immediately reversible in response to changing tactical requirements.

-- Med STO-4: Patient movement capabilities

Create technology solutions and innovations to improve patient movement, i.e., casualty evacuation (CASEVAC) and medical evacuation (MEDEVAC) both within the joint theatre of operations as well as evacuation to a definitive source of care outside of theatre. Develop light weight stretchers and the means to reduce the number of dismounted Marines that are required to rapidly transport a non-ambulatory Marine.

-- Med STO-5: Health surveillance, intelligence, and preventive medicine capabilities

Develop technologies and systems to improve comprehensive health surveillance at all echelons of care, quickly share medical intelligence from all relevant sources, and provide a full-spectrum of preventive medicine services.

-- Med STO-6: Medical logistics and infrastructure support capabilities

Improve existing systems and technologies, while developing new technical innovations that accurately plan for future medical logistics operations, optimize current joint medical logistics operations and develop sustainable health service support to current and future joint force operations.

-- Med STO-7: Warfighter physiology[42]

Develop technologies that will identify Marines' responses to prolonged combat stress by assessing multiple interdisciplinary indicators such as psychological, physiological, endocrinological, or immunological factors simultaneously. The technologies would be able to provide the information quickly and unobtrusively so that the effects of stress that may influence combat effectiveness, such as mental or physical fatigue, can be quickly identified and mitigated.

-- Med STO-8: Physical readiness conditioning and nutrition monitoring[43]

Develop solutions that would assist Marines in monitoring exercise intensity, frequency, duration, recovery, and/or specific physiological indicators of aerobic training to prevent over-or under-training. Solutions should increase self-awareness by assessing physiological indicators, physical activity, and/or fuel (food) usage. This will enable Marines to maximize their physical training by knowing what foods are optimal for recovery, when to increase exercise intensity, frequency, duration, or increase recovery (by resting or decreasing training volume).

[1] Army Science & Technology Master Plan 2007 of Mar 2007.
[2] Col Terry L. Bruning "Report of Marine Corps Participation at 2009 ABCA Armies Science and Technology Workgroup (1~BCA S&T WG) Meeting: dated 15 April 2009 w/First Endorsement of Director, Command, Control, Communications and Computers, Headquarters, US Marine Corps Director, Command, Control, Communications dated 20 Apr 2009.
[3] Office of Naval Research SORM, ONRINST 5430.16A page 3-14
[4] Mattis, Lieutenant General J.N., Excerpted from Commanding General's (MCCDC) Command and Control (C2) Intent, 11 April 2006.
[5] UNS for "Satellite Gap" 2003
[6] UNS for "MEF Level Targeting UAV" 2004.
[7] All required S&T related to CBRN capability gaps to be funded by the Joint CBD Program and executed by the Joint Science and Technology Office (JSTO/DTRA).
[8] UNS for "Small Unit Space Transport and Insertion Capability" Jul 2002.
[9] Rhodes, LtGen J.E. Rhodes and Holder, RADM G.S. "A Concept for Future Naval Mine Countermeasures in Littoral Power Projection," 1 May 1998 pg. 4.
[10] UNS for "Exoskeleton" Aug 2004.
[11] USMC "MAGTF Mine Countermeasures Master Plan" Aug 2004, Appendices E & F.
[12] USMC "MAGTF Mine Countermeasures Master Plan" Aug 2004, Appendices E & F and CO, Engineer Center of Excellence 1000 over CO dtd 11 Mar 09.
[13] Distributed Operations Architecture Study, 26 Mar 2007, pg. 12.
[14] There are a number of promising high and directed energy technologies of interest to the Marine Corps to include Electromagnetic Pulse (EMP) Hardening; DC and AC LINAC-Driven Charged Particle Beam (CPB); Directional Acoustic Weaponry; and, Pulsed and CW Terahertz High Power Microwave (HPM) and Millimeter Wave Weapons Technologies.
[15] All required S&T related to CBRN capability gaps to be funded by the Joint CBD Program and executed by the Joint Science and Technology Office (JSTO/DTRA).
[16] Vision & Strategy 2025, pg.23.
[17] UNS for "Predictive Readiness" Mar 2004
[18] Marine Corps Vision & Strategy 2025, June 2008, pg. 23.
[19] Marine Corps Vision & Strategy 2025, June 2008, pg. 23.
[20] Marine Corps Vision & Strategy 2025, June 2008, pg. 14.
[21] Marine Corps Vision & Strategy 2025, June 2008, pg. 15.
[22] Marine Corps Vision & Strategy 2025, June 2008, pg. 23.
[23] Marine Corps Vision & Strategy 2025, June 2008, pg. 15.
[24] Marine Corps Vision & Strategy 2025, June 2008, pg. 9.
[25] Marine Corps Vision & Strategy 2025, June 2008, pg. 6.
[26] Marine Corps Vision & Strategy 2025, June 2008, pg. 9-10.
[27] Force Application Functional Concept, 5 March 2004, pg. 13.
[28] Marine Corps Vision & Strategy 2025, June 2008, pg. 21
[29] Marine Corps Vision & Strategy 2025 Implementation Planning Guidance, December 2008, pg. 13
[30] Following Urgent UNS documents refer: "Non-Lethal Tube Launched Munition (VENOM)," "Long Range Non-Kinetic Non-Lethal Weapons," "Laser Dazzlers," "Untethered Non-Lethal Weapons Capability," and "Long Range Acoustic Devices." In addition, the Mission Payload Module (MPM) CDD, DRAFT Escalation of Force (EoF) ICD, and Joint Non-Lethal Weapons Directorate CBA consistently reflect these standards of need.
[31] USMC NLW Strategy dated 2005.
[32] UNS for "Gunship Advanced Combined Arms Weapon Suite" dated May 02.
[33] Urgent UNS for "Vehicle Stopping," the "Portable Vehicle Arresting Barrier "ORD, USMC NLW Strategy, and USMC NLW Annual NL Requirements.
[34] UNS for "Visual Marking System for Urban CAS" Sep 2004.
[35] Marine Corps Vision & Strategy 2025, June 2008, pg. 23.
[36] Flynn, LtGen George J, "Seabasing for the Range of Military Operations, dated 26 March 2009,
[37] Corps Vision & Strategy 2025, June 2008.
[38] Naval Aviation Enterprise Science & Technology Strategic Plan, 1 July 2006.
[39] Naval Aviation Enterprise Science & Technology Objectives, April 2008.

[40] Director, CDD "Letter of Interest in Continuation of the Joint Heavy Lift (JHL) Concept of Refinement and Solution Development," 22 June 2007.
[41] Marine Corps Vision & Strategy 2025, June 2008, pg. 22.
[42] Marine Corps Vision & Strategy 2025, June 2008, pg. 14.
[43] Marine Corps Vision & Strategy 2025, June 2008, pg. 14.

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